

Fear, Complexity, & Environmental Management in the 21st Century

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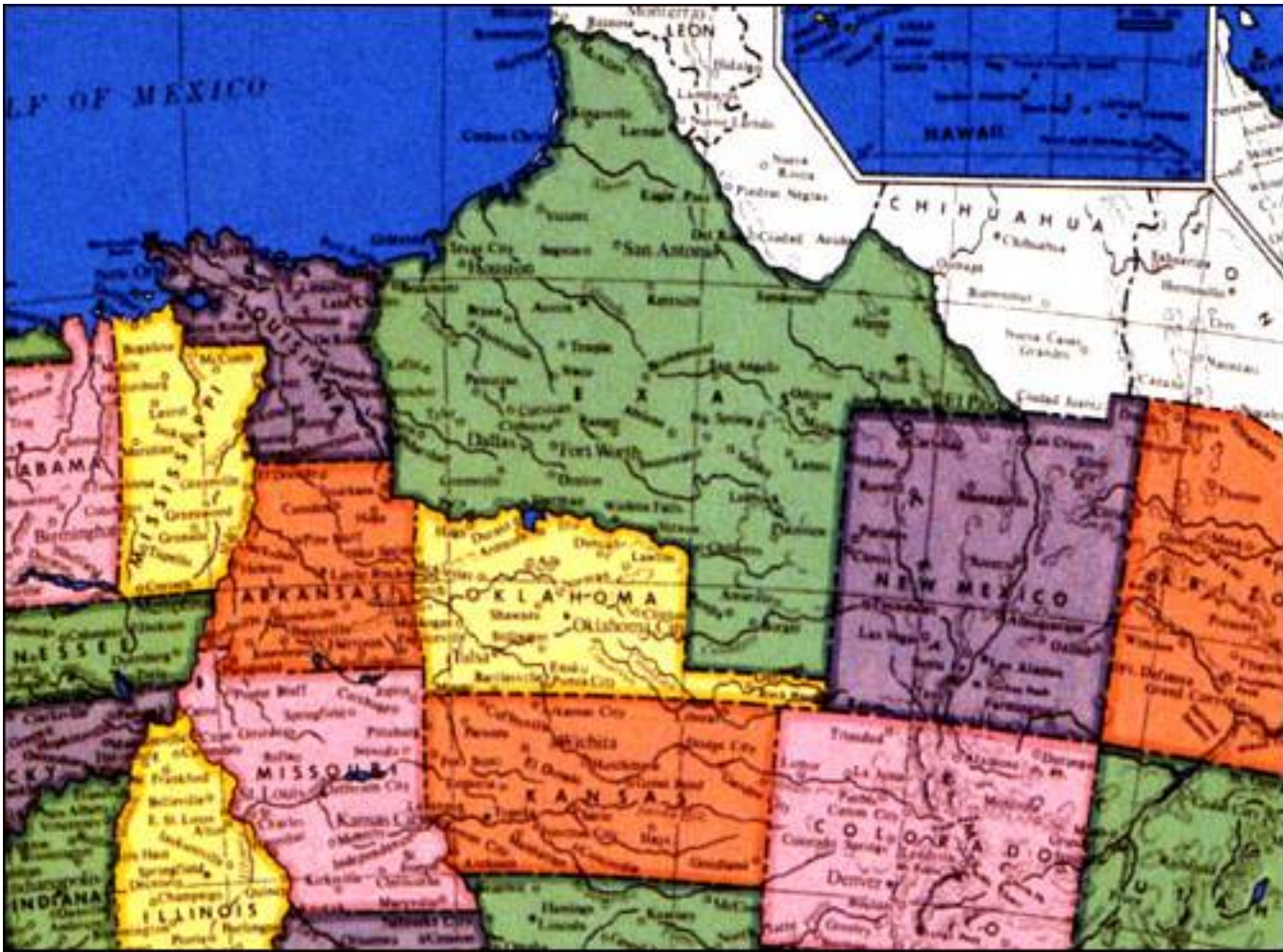
By

Michael Crichton

I am going to challenge you today to revise your thinking, and to reconsider some fundamental assumptions. Assumptions so deeply embedded in our consciousness that we don't even realize they are there. Here is a map by the artist Tom Friedman, that challenges certain assumptions.



Seen close up.



But the assumptions I am talking about today represent another kind of map—a map that tells us the way the world works. Since this is a lecture on complexity, you will not be surprised to hear that one important assumption most people make is the assumption of linearity, in a world that is largely non-linear. I hope by the end of this lecture that the meaning of that statement will be clear. But we won't be getting there in a linear fashion.

Some of you know I have written a book that many people find controversial. It is called *State of Fear*, and I want to tell you how I came to write it. Because up until five years ago, I had very conventional ideas about the environment and the success of the environmental movement.

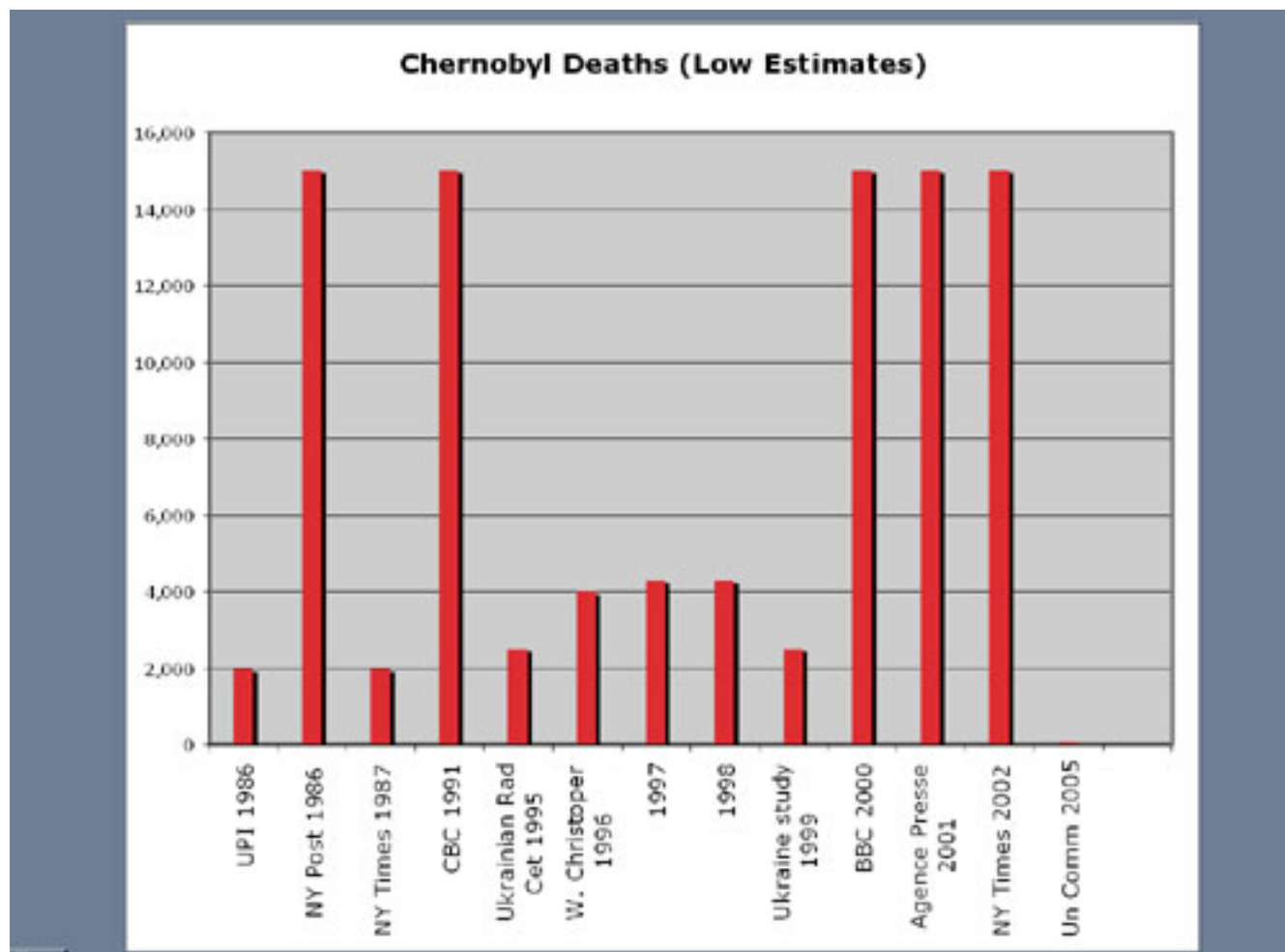
The book really began in 1998, when I set out to write a novel about a global disaster. In the course of my preparation, I rather casually reviewed what had happened in Chernobyl, since that was the worst manmade disaster in recent times that I knew about.

What I discovered stunned me. Chernobyl was a tragic event, but nothing remotely close to the global catastrophe I imagined. About 50 people had died in Chernobyl, roughly the number of Americans that die every day in traffic accidents. I don't mean to be

gruesome, but it was a setback for me. You can't write a novel about a global disaster in which only 50 people die.

Undaunted, I began to research other kinds of disasters that might fulfill my novelistic requirements. That's when I began to realize how big our planet really is, and how resilient its systems seem to be. Even though I wanted to create a fictional catastrophe of global proportions, I found it hard to come up with a credible example. In the end, I set the book aside, and wrote *Prey* instead.

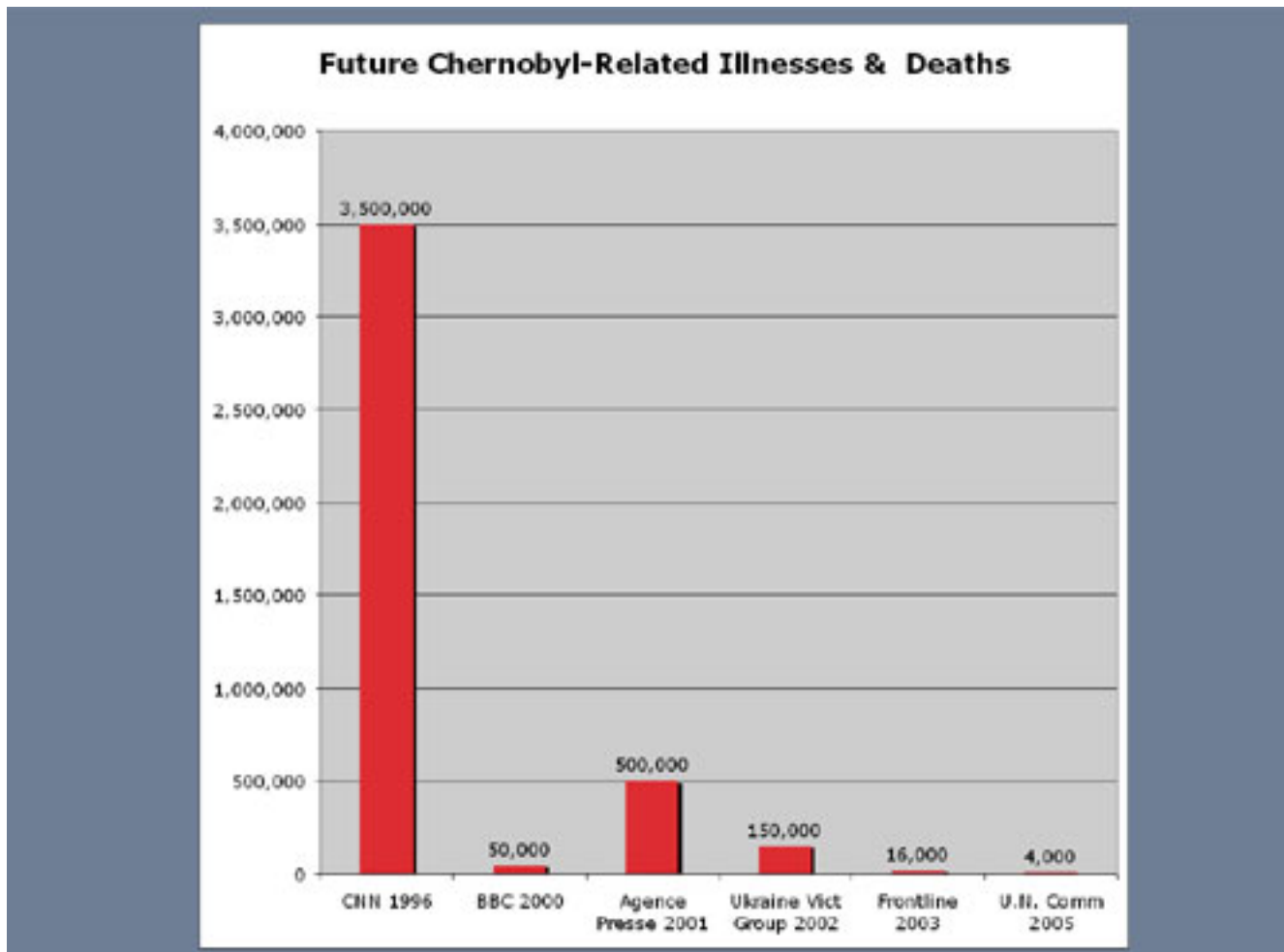
But the shock that I had experienced reverberated within me for a while. Because what I had been led to believe about Chernobyl was not merely wrong—it was astonishingly wrong. Let's review the data.



The initial reports in 1986 claimed 2,000 dead, and an unknown number of future deaths and deformities occurring in a wide swath extending from Sweden to the Black Sea. As the years passed, the size of the disaster increased; by 2000, the BBC and New York Times estimated 15,000-30,000 dead, and so on...

Now, to report that 15,000-30,000 people have died, when the actual number is 56, represents a big error. Let's try to get some idea of how big. Suppose we line up all the victims in a row. If 56 people are each represented by one foot of space, then 56 feet is roughly the distance from me to the fourth row of the auditorium. Fifteen thousand people is three miles away. It seems difficult to make a mistake of that scale.

But, of course, you think, we're talking about radiation: what about long-term consequences? Unfortunately here the media reports are even less accurate.



The chart shows estimates as high as 3.5 million, or 500,000 deaths, when the actual number of delayed deaths is less than 4,000. That's the number of Americans who die of adverse drug reactions every six weeks. Again, a huge error.

But most troubling of all, according to the UN report in 2005, is that "the largest public health problem created by the accident" is the "damaging psychological impact [due] to a lack of accurate information...[manifesting] as negative self-assessments of health, belief in a shortened life expectancy, lack of initiative, and dependency on assistance from the state."

In other words, the greatest damage to the people of Chernobyl was caused by bad information. These people weren't blighted by radiation so much as by terrifying but false information. We ought to ponder, for a minute, exactly what that implies. We demand strict controls on radiation because it is such a health hazard. But Chernobyl suggests that false information can be a health hazard as damaging as radiation. I am not saying radiation is not a threat. I am not saying Chernobyl was not a genuinely serious event.

But thousands of Ukrainians who didn't die were made invalids out of fear. They were told to be afraid. They were told they were going to die when they weren't. They were told their children would be deformed when they weren't. They were told they couldn't have children when they could. They were authoritatively promised a future of cancer, deformities, pain and decay. It's no wonder they responded as they did.

In fact, we need to recognize that this kind of human response is well-documented. Authoritatively telling people they are going to die can *in itself* be fatal.

You may know that Australian aborigines fear a curse called "pointing the bone." A shaman shakes a bone at a person, and sings a song, and soon after, the person dies. This is a specific example of a phenomenon generally referred to as "hex death"—a person is cursed by an authority figure, and then dies. According to medical studies, the person generally dies of dehydration, implying they just give up. But the progression is very erratic, and shock symptoms may play a part, suggesting adrenal effects of fright and hopelessness.

Yet this deadly curse is nothing but information. And it can be undone with information.

A friend of mine was an intern at Bellvue Hospital in New York. A 28-year old man from Aruba said he was going to die, because he had been cursed. He was admitted for psychiatric evaluation and found to be normal, but his health steadily declined. My friend was able to rehydrate him, balance his electrolytes, and give him nutrients, but nevertheless the man worsened, insisting that he was cursed and there was nothing that could prevent his death. My friend realized that the patient would, in fact, soon die. The situation was desperate. Finally he told the patient that he, the doctor, was going to invoke his own powerful medicine to undo the curse, and his medicine was more powerful than any other. He got together with the house staff, bought some headdresses and rattles, and danced around the patient in the middle of the night, chanting what they hoped would be effective-sounding phrases. The patient showed no reaction, but next day he began to improve. The man went home a few days later. My friend literally saved his

life.

This suggests that the Ukrainian invalids are not unique in their response, but by the large numbers of what we might call “information casualties” they represent a particularly egregious example of what can happen from false fears.

Once I looked at Chernobyl, I began to recall other fears in my life that had never come true. The population bomb, for one. Paul Ehrlich predicted mass starvation in the 1960s. Sixty million Americans starving to death. Didn't happen. Other scientists warned of mass species extinctions by the year 2000. Ehrlich himself predicted that half of all species would become extinct by 2000. Didn't happen. The Club of Rome told us we would run out of raw materials ranging from oil to copper by the 1990s. That didn't happen, either.

It's no surprise that predictions frequently don't come true. But such big ones! And so many! All my life I worried about the decay of the environment, the tragic loss of species, the collapse of ecosystems. I feared poisoning by pesticides, alar on apples, falling sperm counts from endocrine disrupters, cancer from power lines, cancer from saccharine, cancer from cell phones, cancer from computer screens, cancer from food coloring, hair spray, electric razors, electric blankets, coffee, chlorinated water...it never seemed to end.

Only once, when on the same day I read that beer was a preservative of heart muscle and also a carcinogen did I begin to sense the bind I was in. But for the most part, I just went along with what I was being told.

Now, Chernobyl started me on a new path. As I researched these old fears, to find out what had been said in the past, I made several important discoveries. The first is that there is nothing more sobering than a 30 year old newspaper. You can't figure out what the headlines mean. You don't know who the people are. Theodore Green, John Sparkman, George Reedy, Jack Watson, Kenneth Duberstein. You thumb through page after page of vanished concerns—issues that apparently were vitally important at the time, and now don't matter at all. It's amazing how many pressing concerns are literally of the moment. They won't matter in six months, and certainly not in six years. And if they won't matter then, are they really worth our attention now?

But as David Brinkley once said, “The one function TV news performs very well is that when there is no news we give it to you with the same emphasis as if there were.”

Another thing I discovered was that attempts to provoke fear tended to employ a certain

kind of stereotypic, intense language. For example, here is a climate quote:

We Must Deal With Climate Change Now!

"We simply cannot afford to gamble ... by ignoring it. We cannot risk inaction. Those scientists who say we are merely entering a period of climatic instability are acting irresponsibly. The indications that our climate can soon change for the worse are too strong to be reasonably ignored."

1978, Lowell Ponte, *The Cooling*, p 237

Familiar language, isn't it? But it's not about global warming, it's about global *cooling*. Fear of a new ice age. Anybody here worried about a new ice age? Anybody upset we didn't act now, back then, to stockpile food and do all the other things we were warned we had to do?

Here is a quote from a famous 1970s computer study that predicted a dire future for mankind unless we act now:

The World in Peril

“We are unanimously convinced that rapid, radical redressment of the present unbalanced and dangerously deteriorating world situation is the primary task facing mankind...Concerted international measures and joint long-term planning will be necessary on a scale and scope without precedent.This supreme effort is....founded on a basic change of values and goals at individual, national and world levels...”

1972, Meadows et. al, The Limits of Growth

And here is a third quote, from Paul Ehrlich's population bomb book:

Pain May Be Intense

"The operation will demand many apparently brutal and heartless decisions. The pain may be intense. But the disease is so far advanced that only with radical surgery does the patient have a chance of survival."

1968, Paul Ehrlich, The Population Bomb

Here is one from the UN.

Greatest Threat In History

"History offers no example of a parallel threat on a global, national or even local scale. To "wait and see" invites disaster. Only the long-term threats of global warming, oxygen loss, exhaustion of other basic resources in the oceans and continents as well as the eventual possibility of an earth-asteroid collision demand worldwide action on a similar scale...A worldwide strategic mobilization ...similar to the effort required by World War II must be developed in the weeks ahead."

1998, UN Working Group on Informatics

That one is talking about Y2K. By now everybody has forgotten Y2K, so let me remind you what was predicted six years ago.

12 Months of Riots and Lawlessness

"Things are only going to get more confusing... The point of absolute certainty will never come... Nevertheless, I am assuming at least a twelve-month disruption of basic goods and services, including periods of:

No electrical power

No clean water

No telecommunications

Shortages of food, gasoline, clothing, and all retail goods

Widespread bank failures and inaccessibility of funds

Stock market crash

Dramatic drop in real estate values

Economic Depression

Widespread Unemployment

Civil unrest, including protests, riots and general lawlessness"

1999, Michael S. Hyatt, The Y2K Personal Survival Guide

And this was one of the milder ones. Another book predicted the "meltdown of civilization as we know it." Can't get any stronger than that.

The End of Civilization

"Some analysts predict a turbulent time of social upheaval with starvation in some cities, no police force to protect people ... and a meltdown of civilization as we know it."

1999, Bates et al, The Y2K Survival Guide and Cookbook

What actually happened on January 1, 2000? Essentially, nothing.

But once again, notice the urgent language. The situation is desperate, unprecedented action is necessary, ordinary values must be pushed aside, anyone who disagrees is dangerous and reactionary. Terror, fear, and the end of civilization.

Now you may be thinking, wait a minute, Y2K *was* a real problem and the concerns, even if exaggerated, nevertheless mobilized people and led to success. This is a common but erroneous view. Here is the UN again.

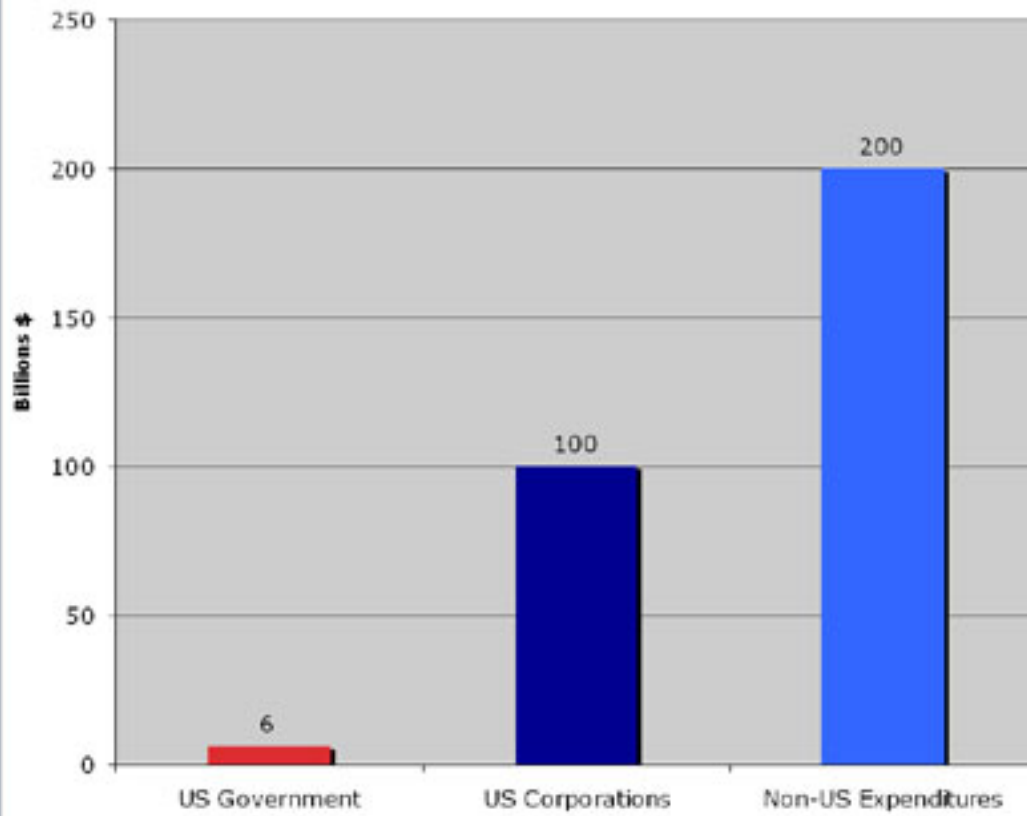
Governments Save the Day

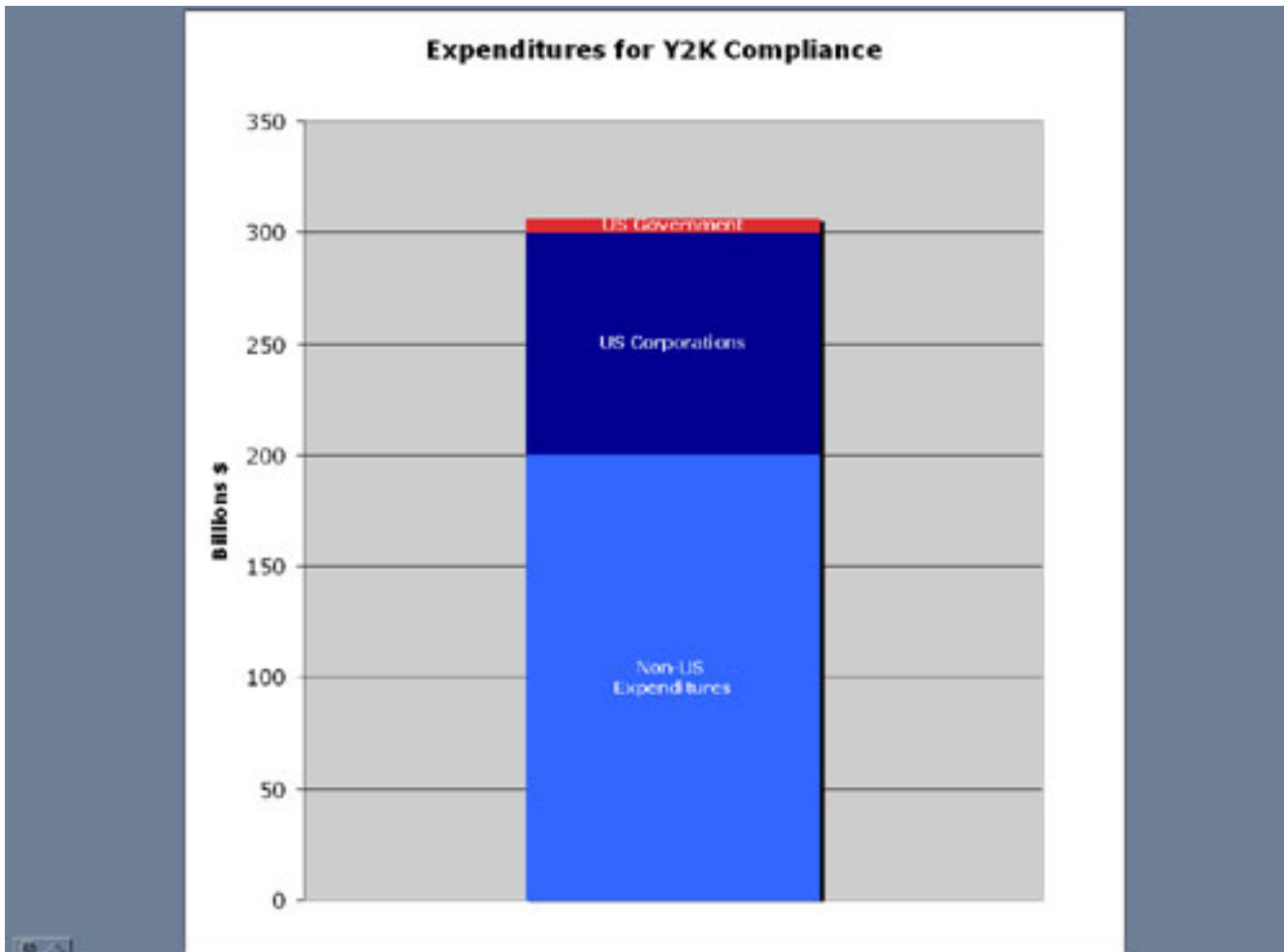
"During the first months of the new century only minor problems were reported.... The governments... can congratulate themselves for passing the Y2K challenge."

U.N. Website: <http://www.unesacpe.org/56/e1183e.htm>

So governments can congratulate themselves! The only problem is, they have no reason to congratulate themselves, because governments didn't solve this problem. The US government spent 6 billion dollars. But Citibank alone spent nearly 1 billion. And total US expenditures were on the order of 100 billion, which means the government spent 6% of the total needed to fix the problem.

Expenditures for Y2K Compliance





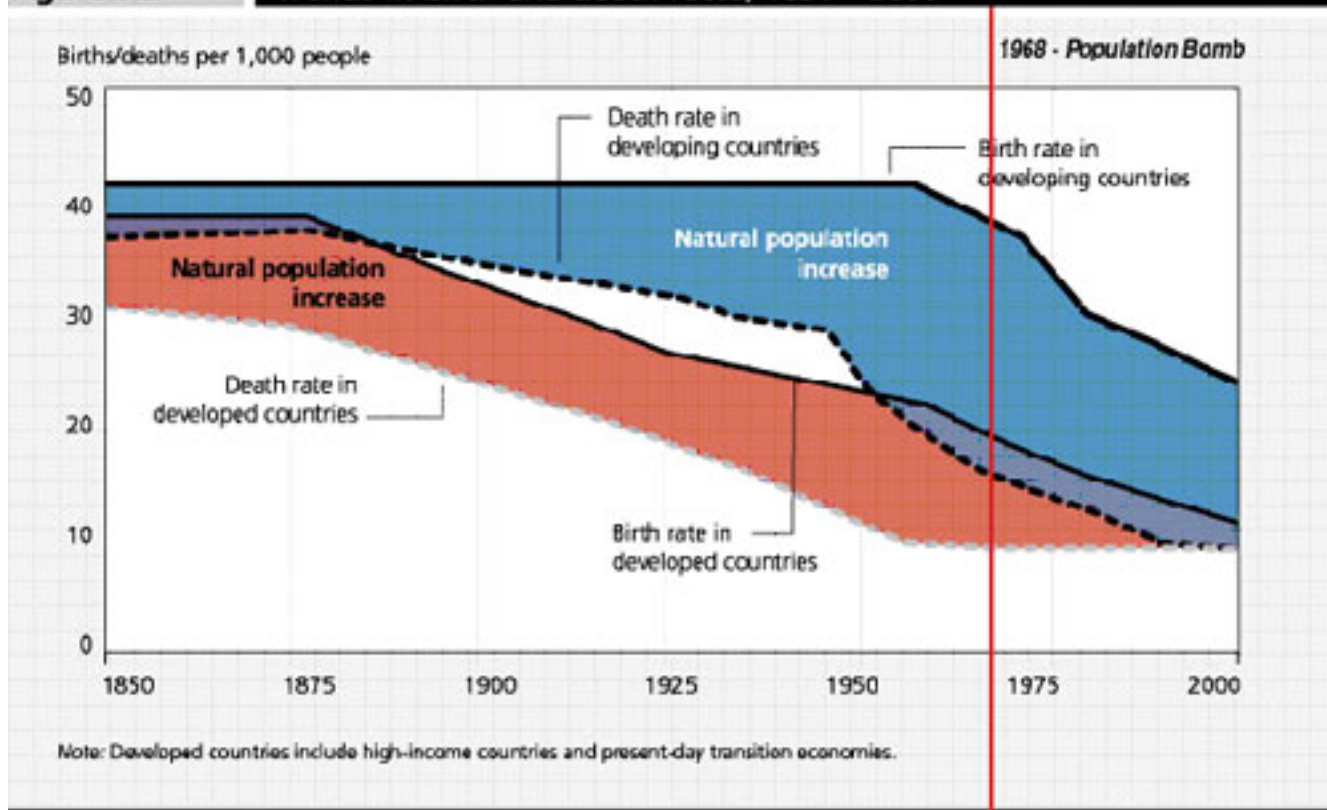
Would Citibank have spent the money to fix its Y2K problem without government urging? Of course, because not to do so would have put them out of business. The same is true of other banks and businesses around the world. Yet government takes the credit.

To encourage what is happening anyway is a common procedure in many areas of advocacy. For example, it now seems clear that despite the warnings of Paul Ehrlich and others, we are not going to have a population explosion of 14 billion people and associated mass starvation. How did we avoid this explosion? Because—the head of planned parenthood once explained to me, everybody in the world listened to Ehrlich—and got busy stopping population growth. I was astonished she could be so uninformed about her subject area. Ehrlich may be a celebrity in the west; but his advocacy had little to do with solving the problem of population, *because that problem was already being solved by itself, at the time he wrote his book.*

Here is a graph from the World Bank. Not very easy to understand, but then, it's the World Bank.

Figure 3.2

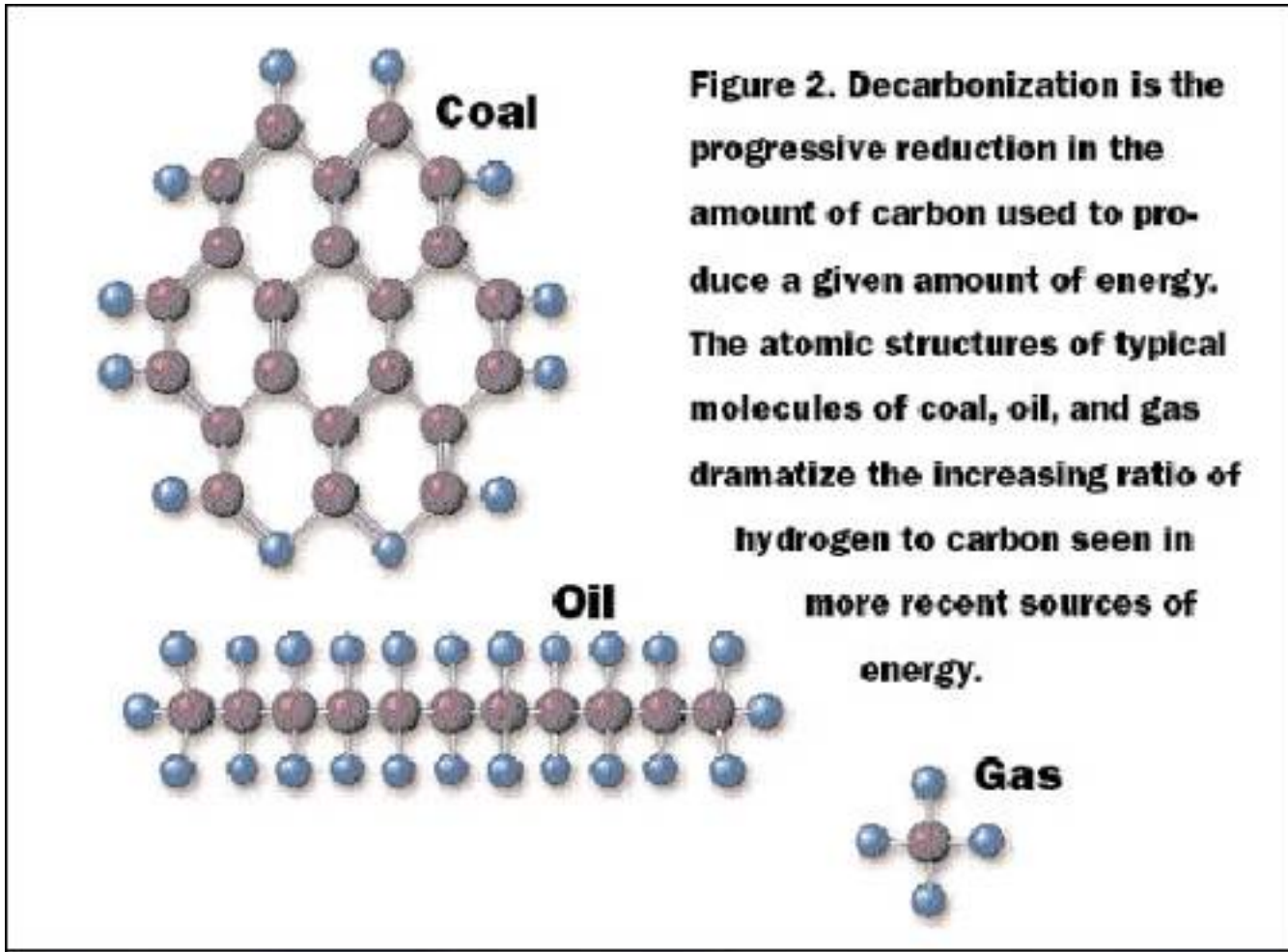
Trends in birth and death rates, 1850 – 2000



Notice that in 1968, when Ehrlich published his book *The Population Bomb*, world fertility was already in decline. Ehrlich was thus urging people to do what they had already been doing for about 10 years. It's not clear whether he knew this or not. But certainly when he said, "The battle to feed all of humanity is over....At this late date nothing can prevent a substantial increase in the world death rate..." he was simply wrong. As you see, after his book appeared the death rate remained flat in developed countries, and it continued to fall for another 10 years in developing countries.


Ehrlich's procedure—crying out in desperation to urge what's already happening—isn't unique. We have a contemporary example in the call of politicians and activists to end our dependence on fossil fuels, and move to a "carbon neutral" lifestyle. Their call to action is, however, a bit late.

According to Jesse Ausubel of the Rockefeller Institute, industrialized nations have been decarbonizing their energy sources for 150 years, meaning we are moving away from carbon toward hydrogen. In other words, the ratio of carbon to hydrogen decreases as you go from wood and hay (1:1) to coal to oil to gas (1:4). Here is an illustration from one of his articles:



Ausubel expects the trend to continue through this century as we move toward pure hydrogen—without the assistance of lawyers and activists. Obviously if a trend has been continuously operating since the days of Lincoln and Queen Victoria, it probably does not need the assistance of organizations like the Sierra Club and the NRDC, which are showing up about a hundred years too late.

Ausubel's ideas are controversial to some, but not to sites like Sustainability Now:



Sustainability Now

...if not now, when? if not us, who?

The Basics
Initiatives
Best Practices
KnowledgeBase
Opportunities

Decarbonization

The decreasing carbon to hydrogen ratio in fuel.

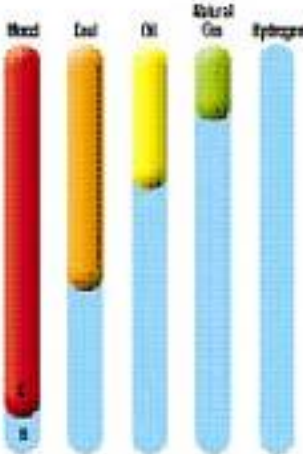
From prehistoric ages, about 750,000 years ago, until the beginning of the 19th century, wood was the main source of energy. Since society has moved from wood, to coal, to oil to natural gas, to - soon- pure hydrogen.

Wood has 10 atoms carbons for 1 atom of hydrogen.

Coal, 1~2 Carbon for 1 hydrogen

Oil, 1 carbon for 2 hydrogen

Natural Gas, 1 carbon for 4 hydrogen.



Burning Carbon produces CO₂ a Green House Gas.
Burning Hydrogen produces water.

Together with energy conservation, Decarbonization of our economy is a sustainable solution to Climate Change.

All right

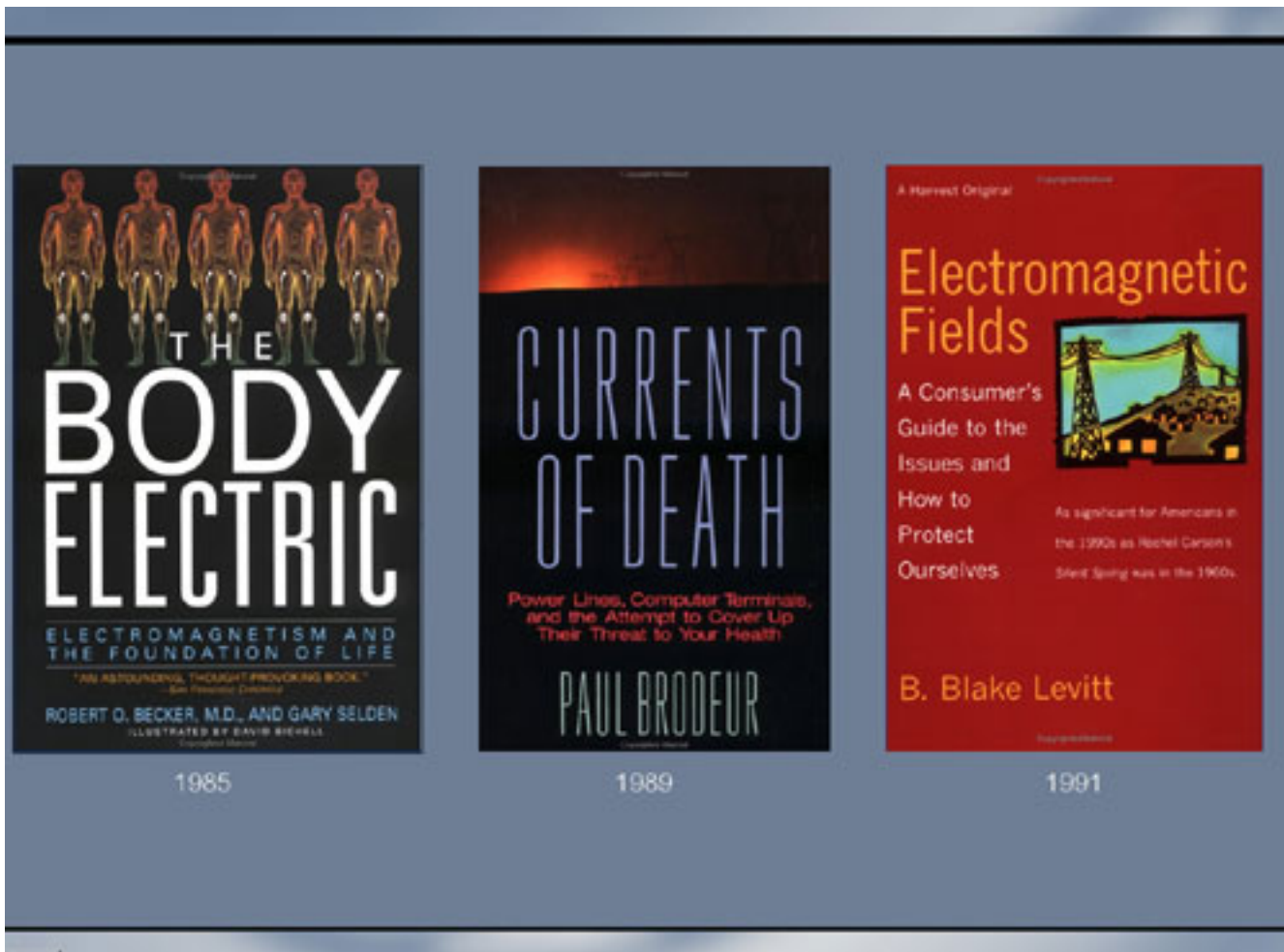
. Then in summary, when I went back to examine old fears, the first thing I found was that newspapers were focused on momentary concerns; the second thing I found was that the language employed was excessively frightening, and the third thing I found was that a lot of advocacy was encouraging what was happening anyway. But I learned some other things, too.

One interesting feature is the tendency to reversals: a benefit becomes a hazard and then becomes a benefit again. Butter is good, then bad, then good again. Saccharine is good, then bad, then good. But this is also true for some much larger scares, like cancer and

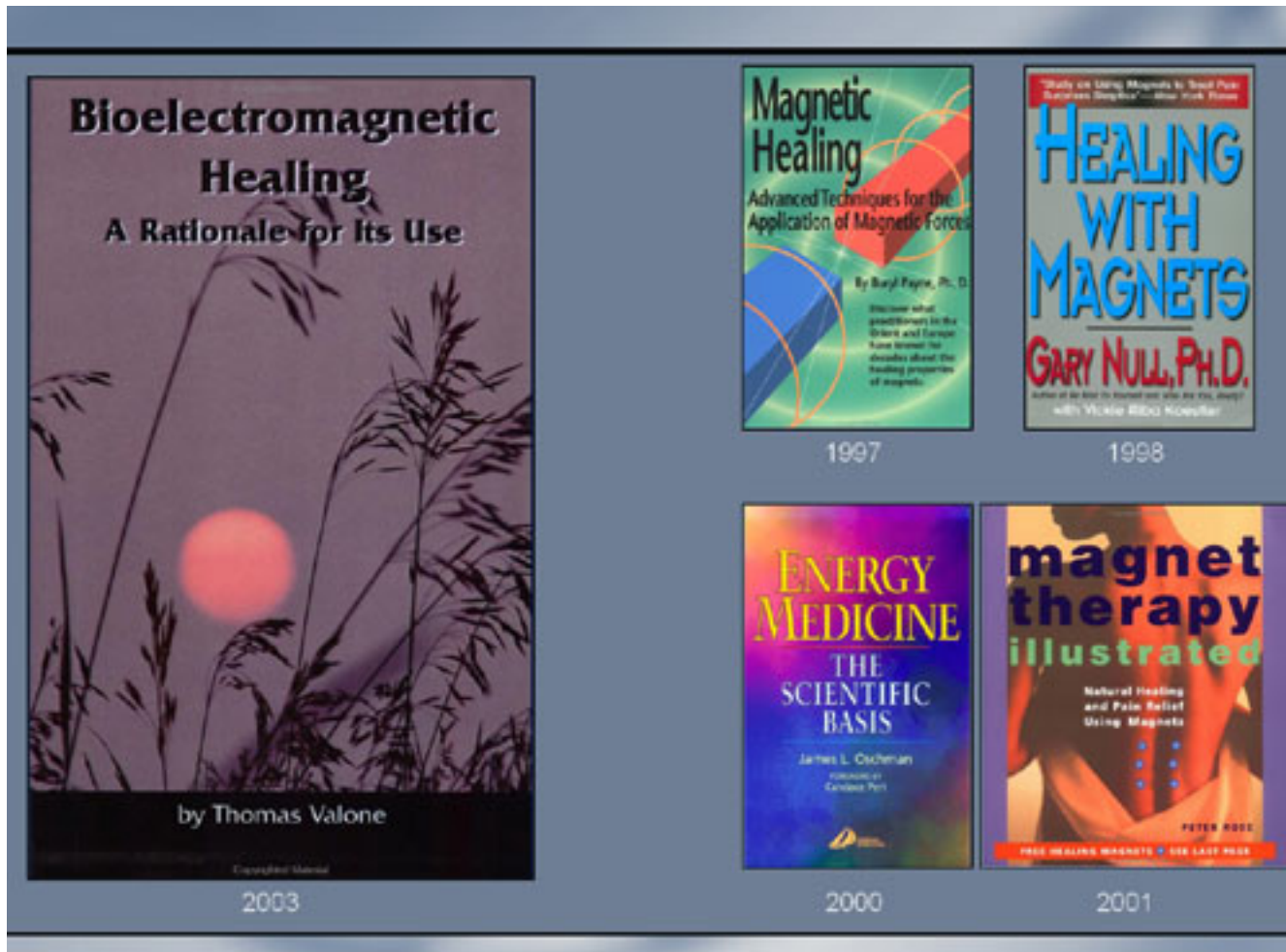
powerlines, which hit the media in 1989.

You can chart the progression by looking at book covers. Before 1989, there were books like *The Body Electric*, which saw magnetic fields as necessary for life.

Then came Paul Brodeur's articles in *The New Yorker* magazine. Brodeur's strong position drew support for his view, with books that offered "A Consumer's Guide to [Electromagnetic Fields] and How to Protect Ourselves."



But then a funny thing happened. After about a decade, magnetic fields were rehabilitated. Again, you can chart the progression in book covers:



And finally, in a complete reversal, we now have people selling magnets to *increase* your exposure to magnetic fields, since “nature is drastically depleted” of this vital health component.

{ NEWS & NOTES }

Sleep "Smart" With Magnetico Sleep Pads

Sleep "smart" as your Magnetico Sleep Pads works for you! Dr. Bonlie's design of Sleep Pad is unlike all others, it is placed under your mattress – giving you magnetism as we get it naturally from the earth. Since nature is drastically depleted, this environmental supplement is incredibly important. Sleep is about restoring and rebuilding.

Magnetico's product is an integral energy booster in that process.

Crystal P., a busy mom and model, says "My stress level is down; my vitality is up! It has made an incredible turnaround in my health!"

Osteoporosis? Call 800-265-1119 for their special offer.

Visit www.magneticosleep.com for more information.

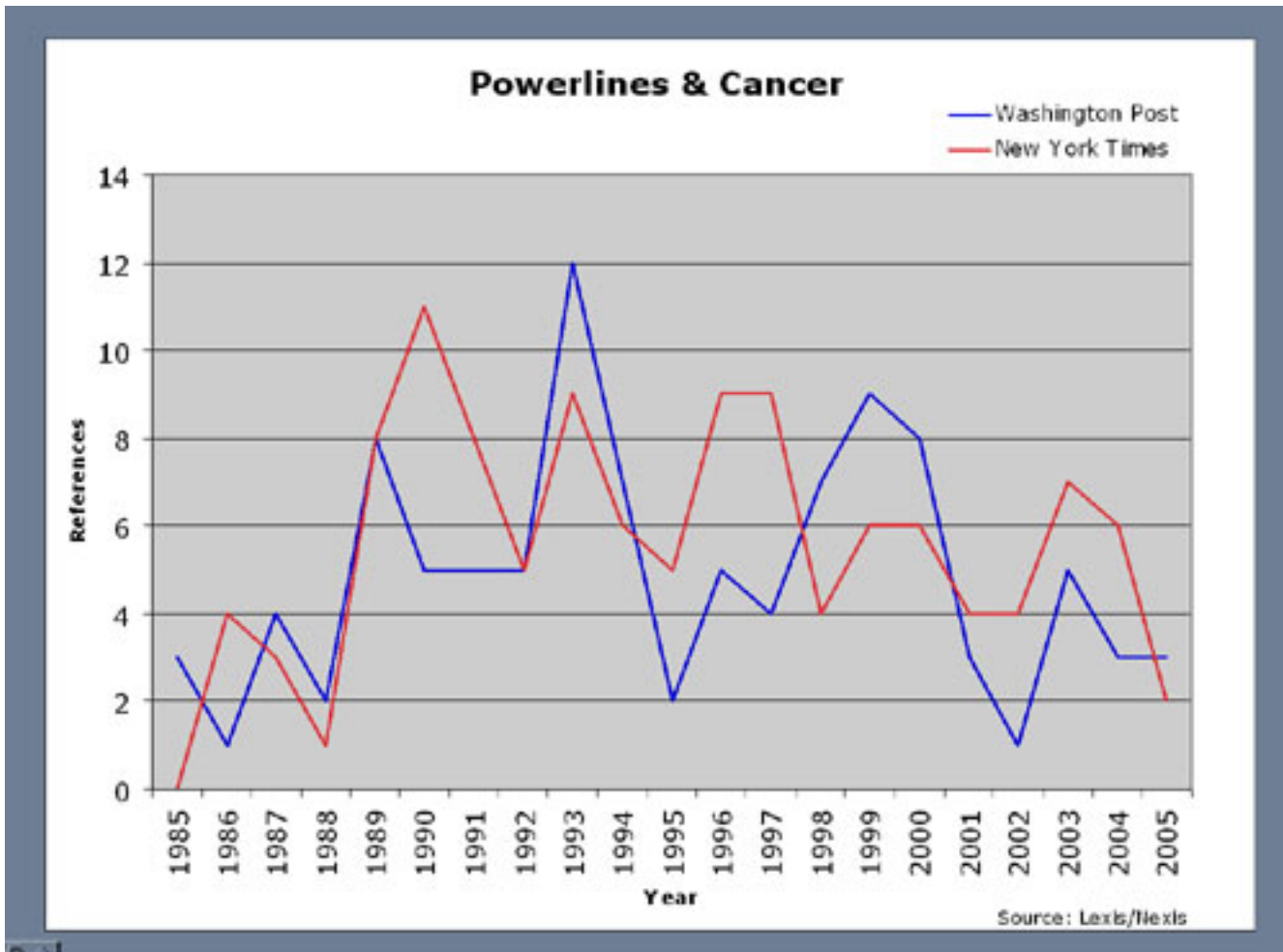


And so we complete the circle, from fear to selling point, from magnetic fields that are too powerful for health, to fields that are too weak for health.

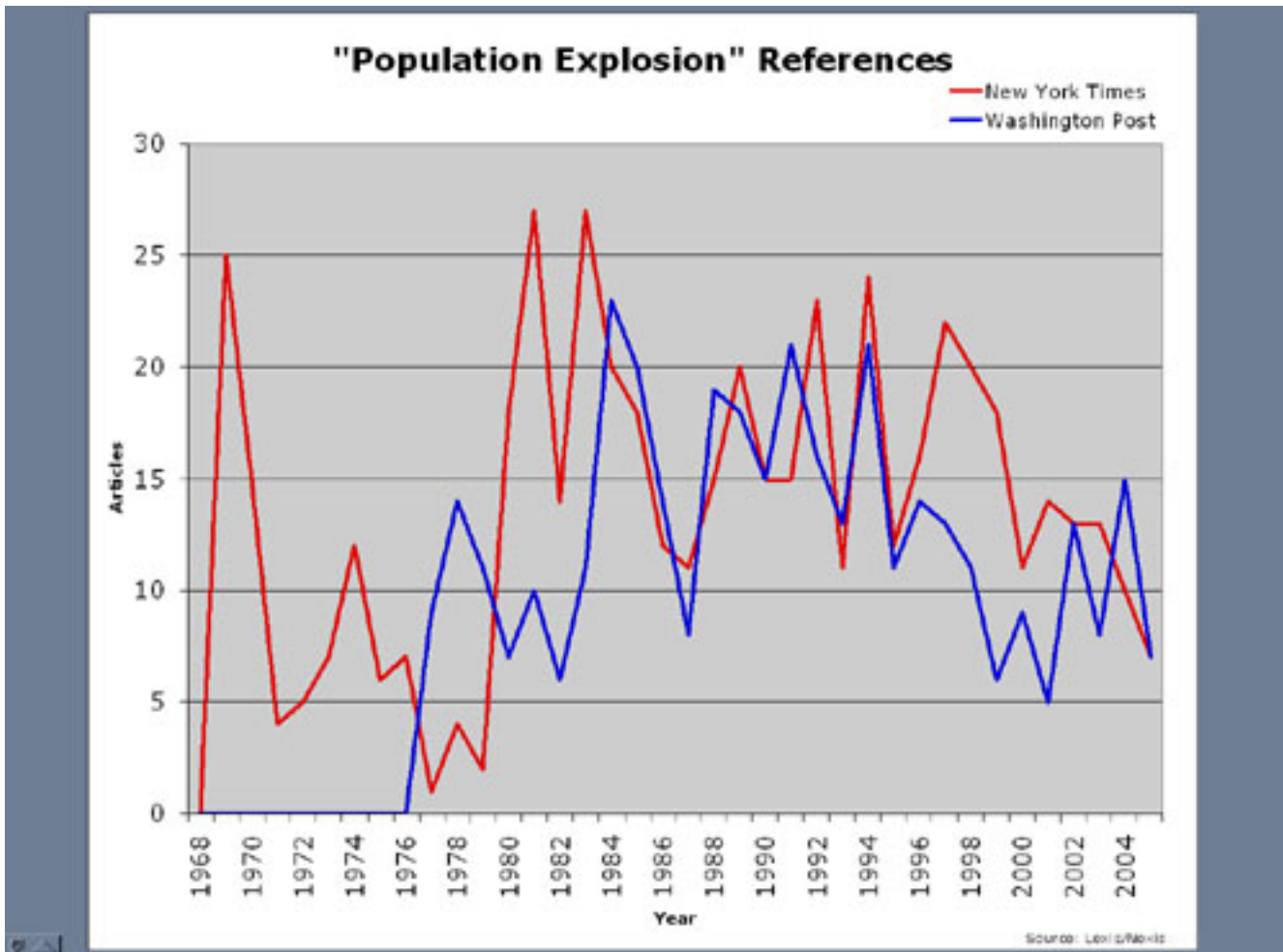
Of course, rather than buying these magnets, you could just stand alongside a power line. Or sit with your back to a TV set. Snuggle up to a kitchen appliance. There's lots of ways to increase your exposure to healthful magnetic fields.

I am reviewing these past fears not to make fun of them, but because I think this back-and-forth quality of fears that suddenly rise and subside is symptomatic of a deeper problem that afflicts all modern environmental thinking—a problem we must address.

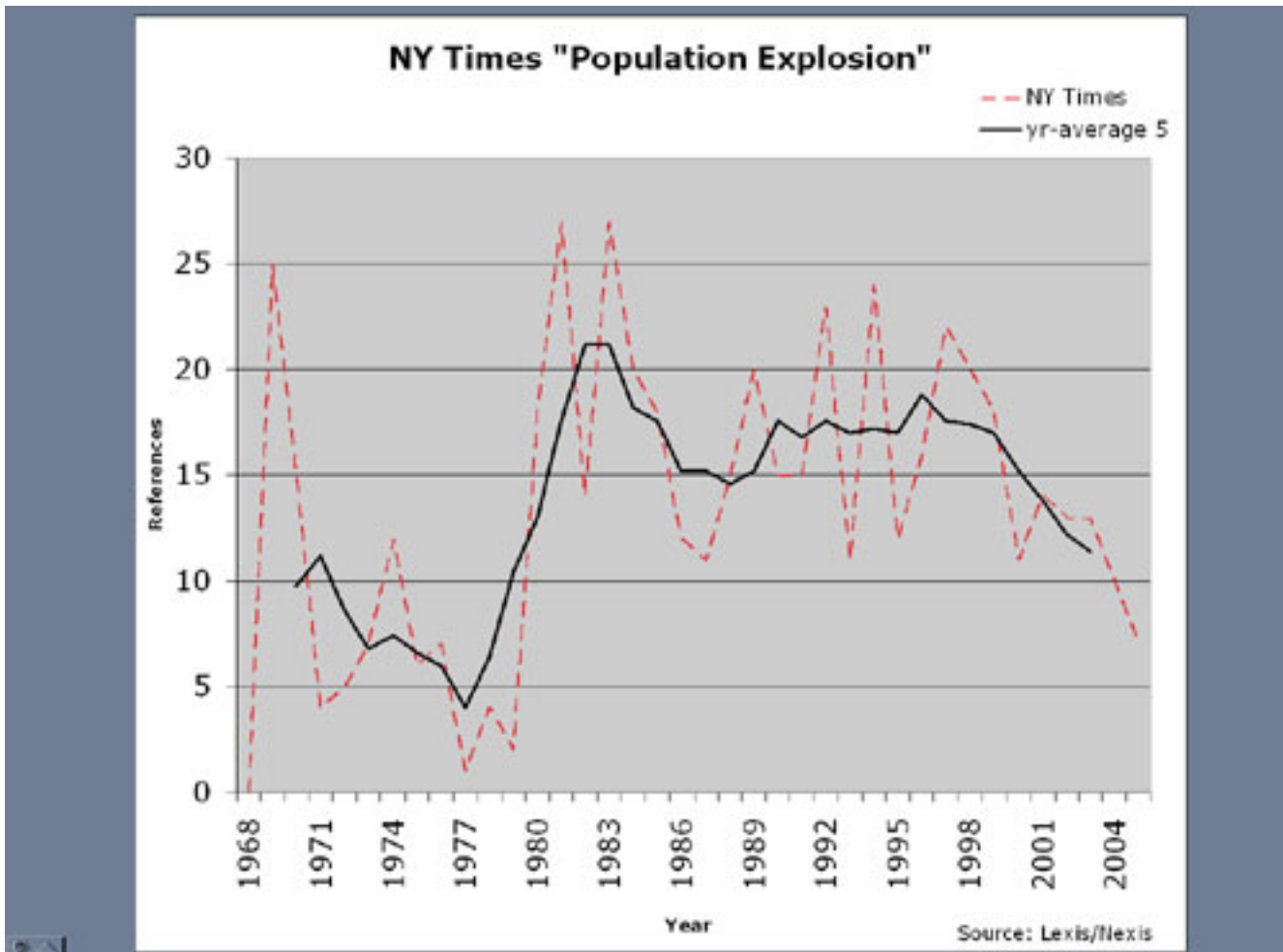
Meanwhile, the fears continue to rise and fall. Let's look at some graphs of past fears. To get a rough idea of the visibility of these fears, I did a word search on Nexis for two newspapers, the *Washington Post* and the *New York Times*. These provide very rough measures, but they will show you a trend. Here's the graph for Powerlines and Cancer.



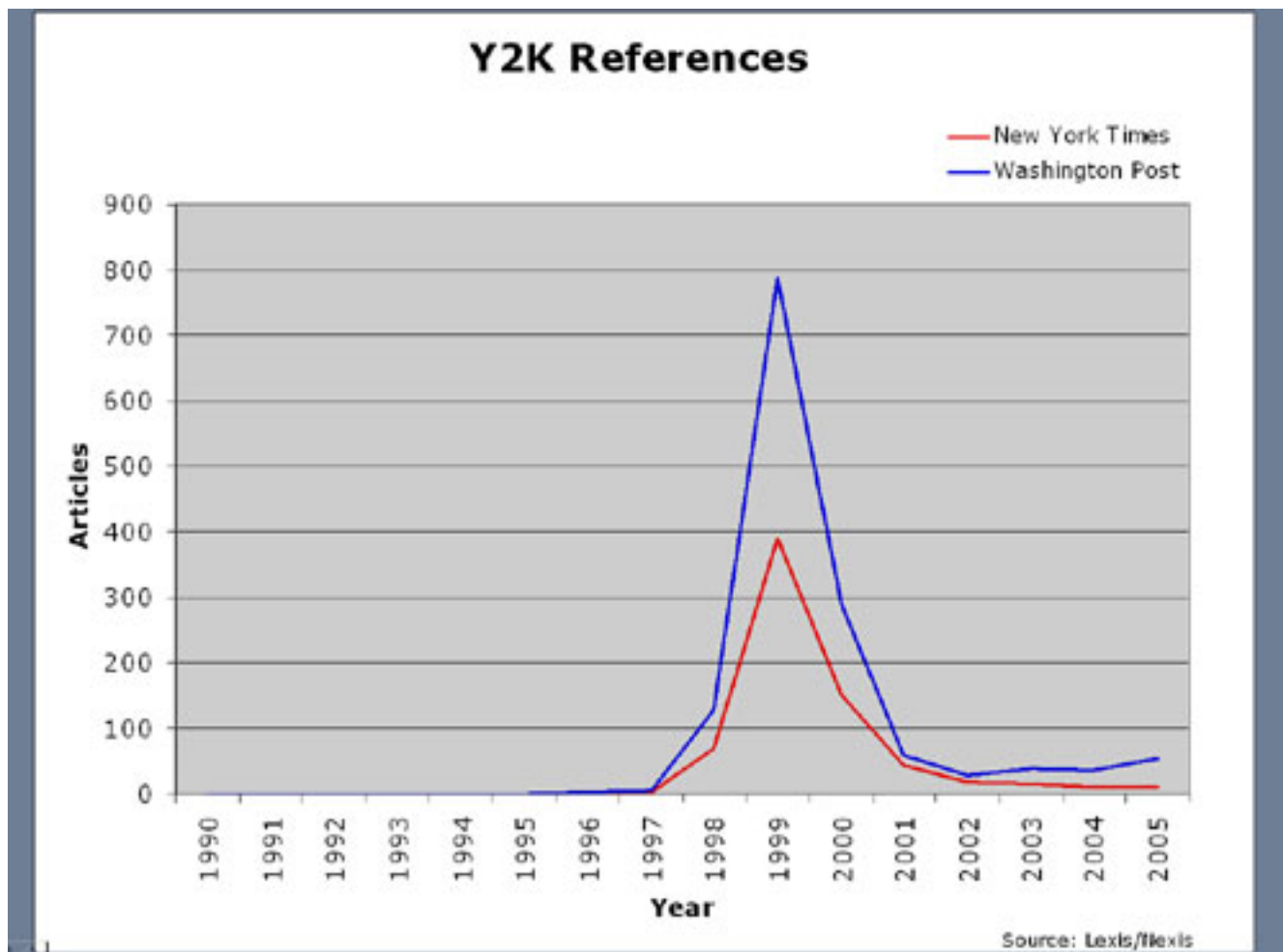
A peak following Brodeur's book in 1989, then a slow decline as the thesis unravels. A similar sort of pattern for the Population Explosion:



This chart may not be clear to you, but we can run a 5-year average for clarity...



You see a line like this in a stock report, it means sell. And finally, here's a much sharper peak for Y2K.



As you see, a sudden spike—2 articles a day, in the *Post* in 1999—and then a collapse to almost nothing. The later drift upward appears to have two causes. There's a band called Y2K, and there is a steady trickle of self-congratulatory articles in which people say it's wonderful that we stopped the dreaded crisis in time.

But beyond any given crisis, I want to emphasize the pattern: new fears rise and fall, to be replaced by others that rise and fall. As Mark Twain said, "I've seen a heap of trouble in my life, and most of it never came to pass."

I have suggested that this pattern is, in itself, indicative of a problem in how we approach the environment.

Environmental disputes frequently revolve around conflicts of land use, triggered by a fear. The spotted owl is endangered, and that means that logging in the northwest must stop. People are put out of work, communities suffer. It may be, in ten or thirty years, that we discover logging was not a danger to the spotted owl. Or the issue may remain contentious. My point is that the drama surrounding such disputes—angry marches and press coverage, tree hugging, bulldozers—serves to obscure the deeper problem. We

don't know how to manage wilderness environments, even when there is no conflict at all.

To see what I mean, let's take a case history of our management of the environment: Yellowstone National Park.



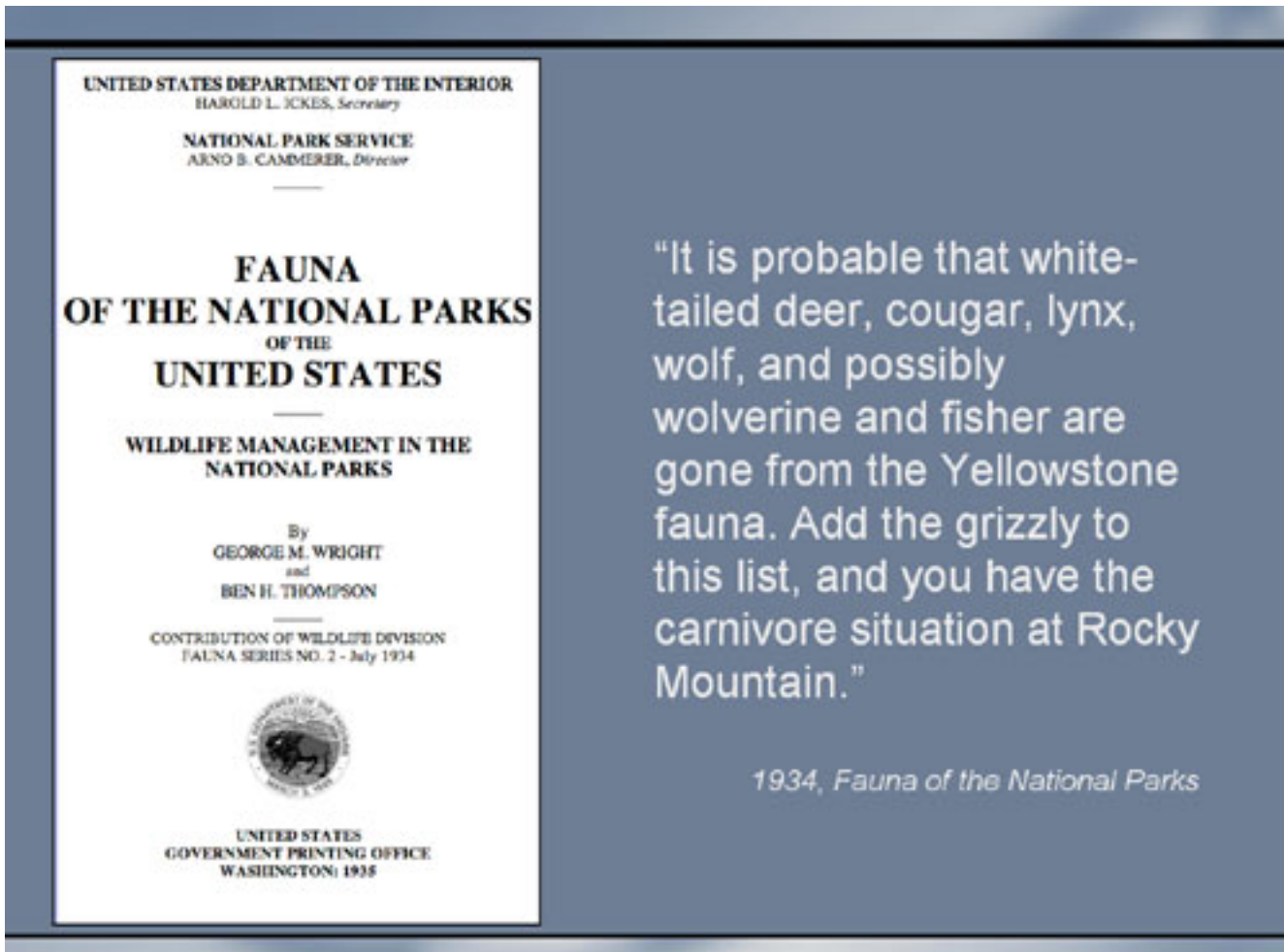
Long recognized as a setting of great natural beauty, in 1872 Ulysses Grant set aside Yellowstone as the first formal nature preserve in the world. More than 2 million acres, larger than Delaware and Rhode Island combined. John Muir was pleased when he visited in 1885, noting that under the care of the Department of the Interior, Yellowstone was protected from "the blind, ruthless destruction that is going on in adjoining regions."

Theodore Roosevelt was also pleased in 1903 when as President he went to Yellowstone National Park for a dedication ceremony.



It was his third visit. Roosevelt saw a thousand antelope, plentiful cougar, mountain sheep, deer, coyote, and many thousands of elk. He wrote, "Our people should see to it that this rich heritage is preserved for their children and their children's children forever, with its majestic beauty all unmarred."

But Yellowstone was not preserved. On the contrary, it was altered beyond repair in a matter of years. By 1934, the park service acknowledged that "white-tailed deer, cougar, lynx, wolf, and possibly wolverine and fisher are gone from the Yellowstone."



What they didn't say was that the park service was solely responsible for the disappearances. Park rangers had been shooting animals for decades, even though that was illegal under the Lacey Act of 1894. But they thought they knew better. They thought their environmental concerns trumped any mere law.

What actually happened at Yellowstone is a cascade of ego and error. But to understand it, we have to go back to the 1890s. Back then it was believed that elk were becoming extinct, and so these animals were fed and encouraged. Over the next few years the numbers of elk in the park exploded. Roosevelt had seen a few thousand animals, and noted they were more numerous than on his last visit.





By 1912, there were 30,000. By 1914, 35,000. Things were going very well. Rainbow trout had also been introduced, and though they crowded out the native cutthroats, nobody really worried. Fishing was great. And bears were increasing in numbers, and moose, and bison.

By 1915, Roosevelt realized the elk had become a problem, and urged "scientific management." His advice was ignored. Instead, the park service did everything it could to increase their numbers.



The results were predictable.



Antelope and deer began to decline, overgrazing changed the flora, aspen and willows were being eaten heavily and did not regenerate. In an effort to stem the loss of animals, the park rangers began to kill predators, which they did without public knowledge.



They eliminated the wolf and cougar and were well on their way to getting rid of the coyote. Then a national scandal broke out; studies showed that it wasn't predators that were killing the other animals. It was overgrazing from too many elk. The management policy of killing predators had only made things worse.

Meanwhile the environment continued to change. Aspen trees, once plentiful in the park, were virtually destroyed by the enormous herds of hungry elk.

With the aspen gone, the beaver had no trees to make dams, so they disappeared. Beaver were essential to the water management of the park; without dams, the meadows dried hard in summer, and still more animals vanished. Situation worsened. It became increasingly inconvenient that all the predators had been killed off by 1930. So in the 1960s, there was a sigh of relief when new sightings by rangers suggested that wolves were returning.



There were also persistent rumors that rangers were trucking them in; but in any case, the wolves vanished soon after; they needed a diet of beaver and other small rodents, and the beaver had gone.

Pretty soon the park service initiated a PR campaign to prove that excessive numbers of elk were not responsible for the park's problems, even though they were. This campaign went on for a decade, during which time the bighorn sheep virtually disappeared.

Now we come to the 1970s, when bears are starting to be recognized as a growing problem. They used to be considered fun-loving creatures, and their close association with human beings was encouraged within the park:





Bear feedings were a spectacle in the 1930s. Postcards treated it humorously:



But now it seemed there were more bears and many more lawyers, and thus more threat of litigation. So the rangers moved the grizzlies away to remote regions of the park. The grizzlies promptly became endangered; their formerly growing numbers shrank. The park service refused to let scientists study them. But once the animals were declared endangered, the scientists could go in.

And by now we are about ready to reap the rewards of our forty-year policy of fire suppression, Smokey the Bear, all that. The Indians used to burn forest regularly, and lightning causes natural fires every summer. But when these fires are suppressed, the branches that drop to cover the ground make conditions for a very hot, low fire that sterilizes the soil. And in 1988, Yellowstone burned. All in all, 1.2 million acres were scorched, and 800,000 acres, one third of the park, burned.

Then, having killed the wolves, and having tried to sneak them back in, the park service officially brought the wolves back, and the local ranchers screamed. And on, and on.

As the story unfolds, it becomes impossible to overlook the cold truth that when it comes to managing 2.2 million acres of wilderness, nobody since the Indians has had the faintest

idea how to do it. And nobody asked the Indians, because the Indians managed the land very intrusively. The Indians started fires, burned trees and grasses, hunted the large animals, elk and moose, to the edge of extinction. White men refused to follow that practice, and made things worse.





To solve that embarrassment, everybody pretended that the Indians had never altered the landscape. These “pioneer ecologists,” as Steward Udall called them, did not do anything to manipulate the land. But now academic opinion is shifting again, and the wisdom of the Indian land management practices is being discovered anew. Whether we will follow their practices remains to be seen.

Now, if we are to do better in this new century, what must we do differently? In a word, we must embrace complexity theory. We must understand complex systems.

We live in a world of complex systems. The environment is a complex system. The government is a complex system. Financial markets are complex systems. The human mind is a complex system---most minds, at least.

By a complex system I mean one in which the elements of the system interact among themselves, such that any modification we make to the system will produce results that we cannot predict in advance.

Furthermore, a complex system demonstrates sensitivity to initial conditions. You can get

one result on one day, but the identical interaction the next day may yield a different result. We cannot know with certainty how the system will respond.

Third, when we interact with a complex system, we may provoke downstream consequences that emerge weeks or even years later. We must always be watchful for delayed and untoward consequences.

The science that underlies our understanding of complex systems is now thirty years old. A third of a century should be plenty of time for this knowledge and to filter down to everyday consciousness, but except for slogans—like the butterfly flapping its wings and causing a hurricane halfway around the world—not much has penetrated ordinary human thinking.

On the other hand, complexity theory has raced through the financial world. It has been briskly incorporated into medicine. But organizations that care about the environment do not seem to notice that their ministrations are deleterious in many cases. Lawmakers do not seem to notice when their laws have unexpected consequences, or make things worse. Governors and mayors and managers may manage their complex systems well or badly, but if they manage well, it is usually because they have an instinctive understanding of how to deal with complex systems. Most managers fail.

Why? Our human predisposition treat all systems as linear when they are not. A linear system is a rocket flying to Mars. Or a cannonball fired from a canon. Its behavior is quite easily described mathematically. A complex system is water gurgling over rocks, or air flowing over a bird's wing. Here the mathematics are complicated, and in fact no understanding of these systems was possible until the widespread availability of computers.

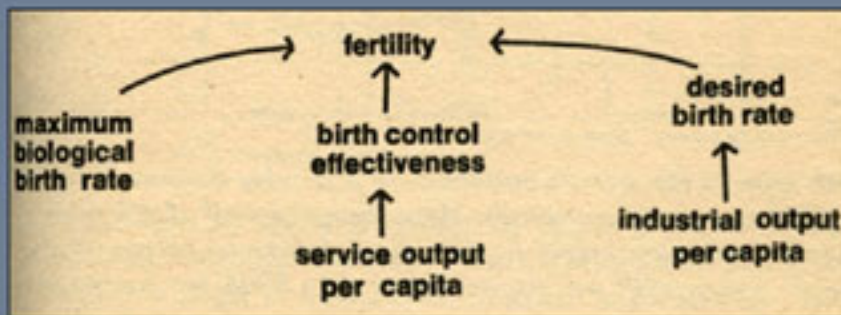
One complex system that most people have dealt with is a child. If so, you've probably experienced that when you give the child an instruction, you can never be certain what response you will get. Especially if the child is a teenager. And similarly, you can't be certain that an identical interaction on another day won't lead to spectacularly different results.

If you have a teenager, or if you invest in the stock market, you know very well that a complex system cannot be controlled, it can only be managed. Because responses cannot be predicted, the system can only be observed and responded to. The system may resist attempts to change its state. It may show resiliency. Or fragility. Or both.

An important feature of complex systems is that we don't know how they work. We don't understand them except in a general way; we simply interact with them. Whenever we think we understand them, we learn we don't. Sometimes spectacularly.

What, then, happened in Yellowstone? I would argue, people thought they understood the system. They thought they understood how nature worked. And they were wrong.

Let's look back to the 1970s, the Club of Rome, Limits of Growth. They produced this chart to explain what regulates fertility.

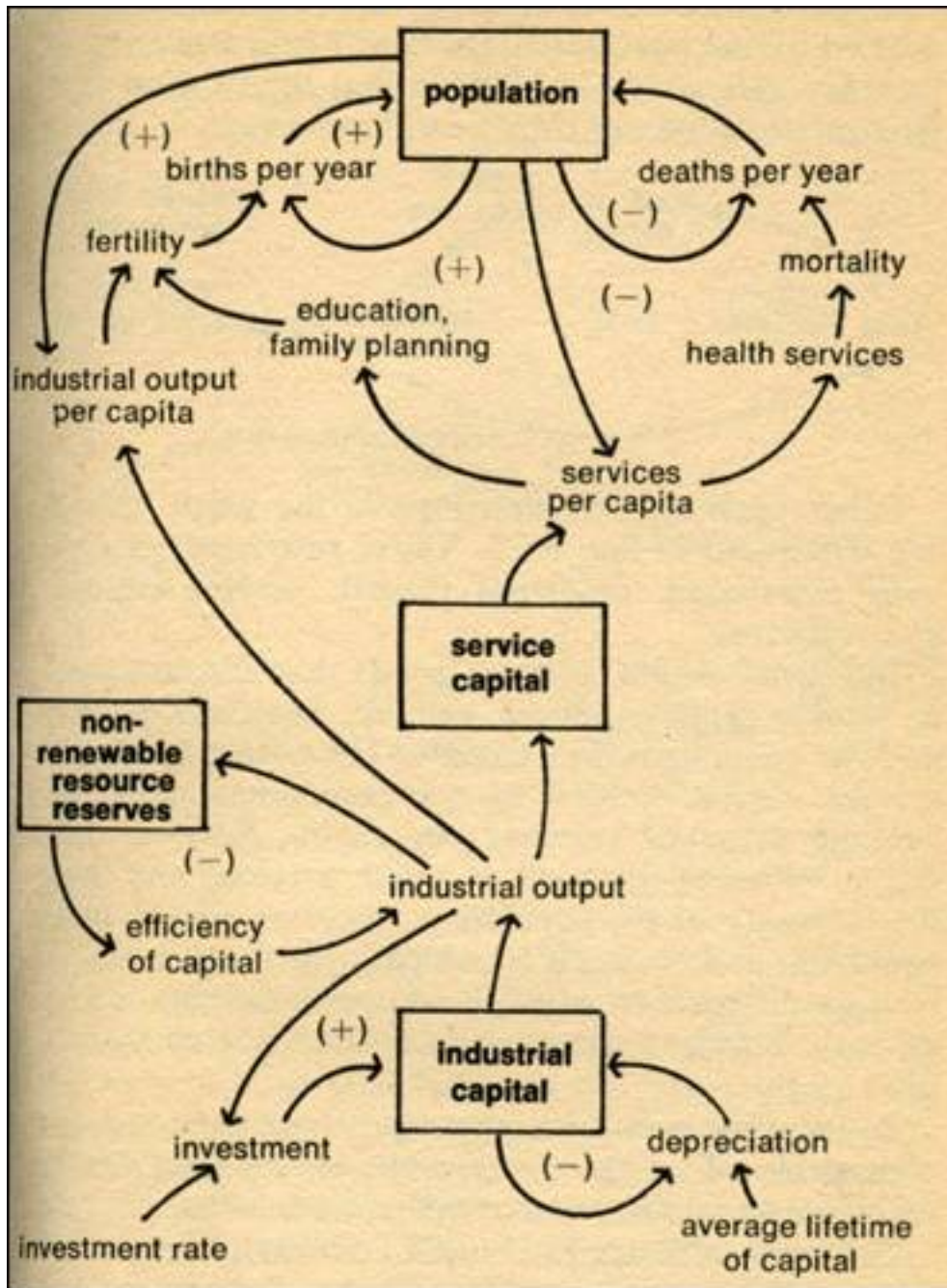


"Most professional demographers no longer believe they can predict precisely the future growth rate, size, composition and spatial distribution of populations."

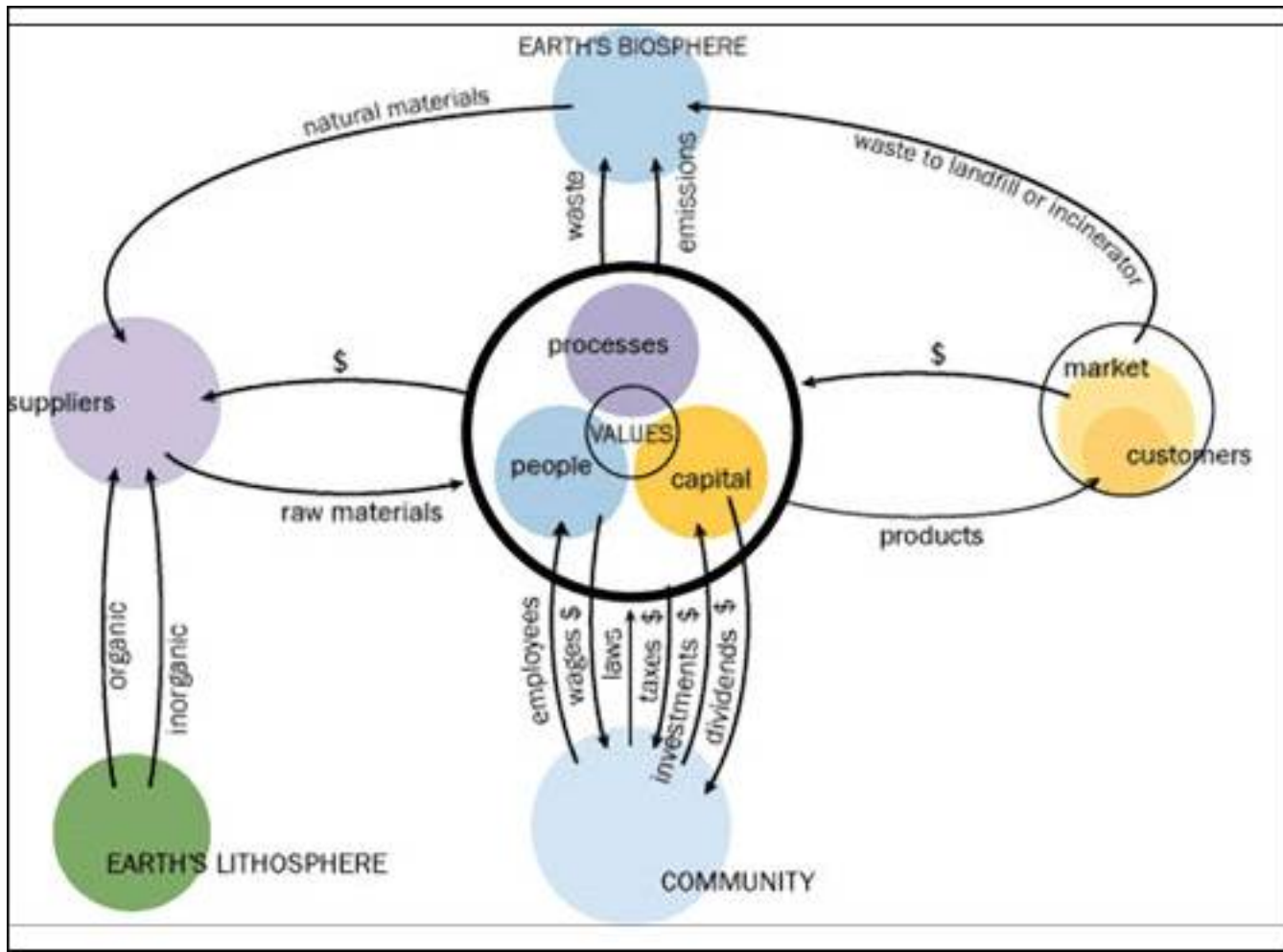
1995, Joel E. Cohen, How Many People Can the Earth Support?

Pretty simple, isn't it? Unfortunately, within 20 years, scientists were saying nobody could predict population in any respect. They were starting to understand how diverse were the influences that impinged on population. They varied from time to time, from country to country. All theories failed.

Here's another from the Limits of Growth, showing the relationship of capital to population. Isn't it great they could fit it all on one page?



The point is, this is highly simplified thinking. But it continues to this day. Here's a modern chart, from a sustainability website. It shows the relationships of pretty much everything: lithosphere, biosphere, market, community, customers. Who makes a chart like this? Who thinks the world operates this way?



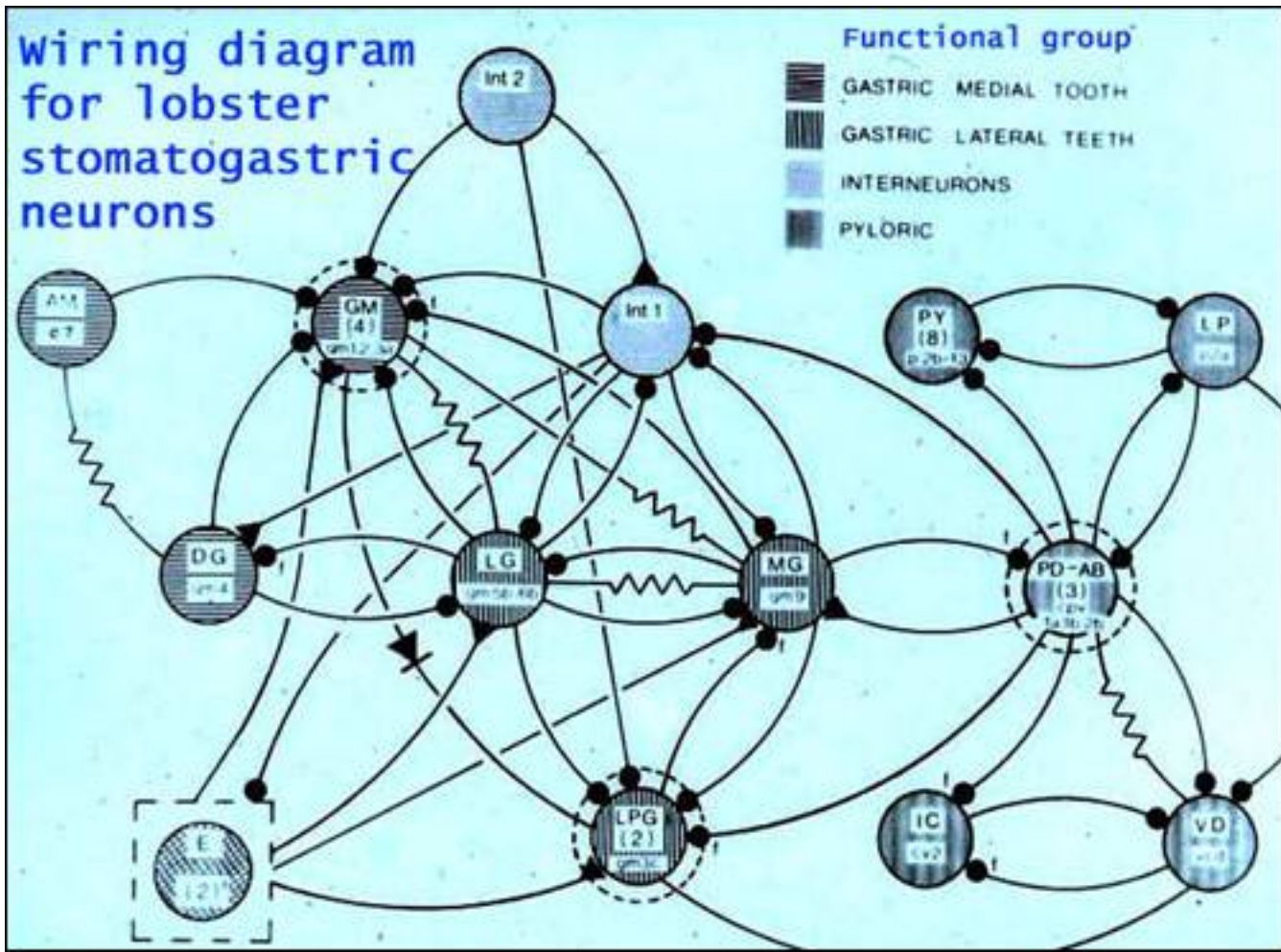
Because look. It does not explain the world.



≠



In fact, the chart on the right, showing everything, is absurdly simple. Nothing in nature is so simple. Here, for example, is a far more complex diagram. It represents the nerves in the stomach of the lobster.



The simplistic schematic diagrams I showed you earlier don't even explain human complex systems, although they are much simpler than natural ones. Here is a financial market and you know—we all know—that if you were to make any single change, say, increase the price of crude oil, or charge a White House aide with a felony, you can not be sure how the financial system will react. Nobody knows.



People make their businesses out of trying to predict financial markets. But nobody can, except insider traders.

Here's an article from the NY Times that says, we can't even know the most fundamental features of our financial system. Is the nation's productivity going up or down? Nobody knows.

ECONOMIC VIEW

DANIEL CROSS

Productivity Is Up. Or Down. Pick Your Statistic.

achers are bombarded with contradictory indicators. Inflation is about to explode. The Fed is spiraling higher. Lately, contradictory figures on a

productivity — the amount of output that can be produced — falls that dreaded inflation. Productivity growth rises as companies are figuring out services while keeping

an, the Federal Reserve's productivity figures are Statistics. Over his 18 years managed to puzzle it — a monotone patois of information in convolut-

s. But when he appeared, Greenspan acknowledged the recent productivity sure of the growth in out-poured sharply in recent. Productivity growth is way flat," he continued, "a con-

that uses output means slowed far less." (Trans-

er" to which Mr. Greenspan productivity. This broad

slates productivity based

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on examining the output and production of the vast American corporate sector. And as Mr. Greenspan noted, that figure had fallen sharply in recent quarters. The year-over-year growth rate of nonfarm business productivity fell from an impressive 4.2 percent in the second quarter of 2004 to a less impressive 1.3 percent in the second quarter of 2005.

The "conceptually equivalent measure" to which Mr. Greenspan referred is an alternate figure published by the bureau: the productivity of nonfinancial corporate businesses. This less broad measure excludes the gigantic financial sector and gauges productivity by examining the incomes of corporations, not their output. And revised figures released after Mr. Greenspan's July 20 testimony show the year-over-year growth rate of nonfinancial corporate productivity has risen sharply, to 3.4 percent in the first quarter of 2005 (second quarter statistics for this measure are not yet available) from 1.1 percent in the second quarter of 2004.

In theory, the two measures of productivity should match up, even though they employ somewhat different methodology and data. And over the long term, they do. "Between 1985 and 2004, both figures grew at about 2 percent per year on average," said Phyllis Otto, supervisory economist at the bureau. But recently, they've gone their separate ways. And that makes the job of detecting the underlying trend in productivity more difficult.

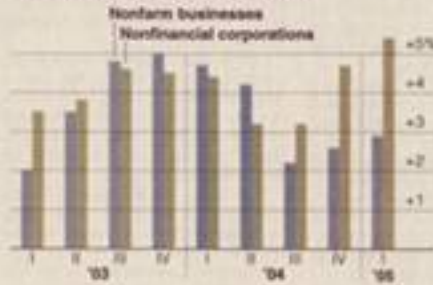
In principle, economists say, the figure that represents the broadest possible swath of the economy is preferable. That would seem to weigh in favor of the more pessimistic nonfarm business number. But there may be good reasons for giving careful weight to the measure of productivity that excludes the financial world. In some ways, it may be more accurate.

After all, it's much easier to calculate productivity

Going Their Separate Ways

In recent quarters, two government measures of productivity have increasingly diverged.

Year-over-year change in productivity of:



Source: Bureau of Labor Statistics. The New York Times

for companies that produce widgets than it is for companies that produce less tangible goods like insurance policies. While the productivity of a factory worker doesn't vary radically from month to month, the productivity of a hedge fund manager can swing wildly from week to week.

What's more, it strikes some economists as strange that including the dynamic financial sector would somehow make the economy seem less productive. "If you

see productivity being dragged down by the financial sector, you have to be a little sun said David Altig, vice president and associate for research at the Federal Reserve Bank of Mr. Altig speaks for himself, not for the Fed.

The divergence could mean there's a big with productivity in the financial sector. And sharp rise in short-term interest rates has cut profits — and hence the productivity — of bar could mean that there's something fishy about bers themselves, or that some as-yet-undetec are muddling the productivity picture. "This-of puzzlement," said J. Bradford DeLong, pro economics at the University of California, Be

BUT the tale of the two productivity figures is a diversity of academic interest. This con has the potential to make the remainder of Mr. Greenspan's tenure more difficult. "ty is in fact slowing, the Fed will have to be m-gressive in raising rates to slow growth," Ma chief economist at Economy.com, said. Other-tionary forces will develop, especially if labor On the other hand, if productivity growth is st-then the Fed doesn't need to be as hawkish.

As is frequently the case when two figures seemingly contradictory stories, the true picture is somewhere in between a drastic fall and a rise. "Given the divergence between the readings," as Mr. Greenspan put it in his inter-way, "a reasonably accurate determination o- test of the recent slowing in productivity grow- parsing into cyclical and secular influences w- the accumulation of more evidence." (Trans- my successor about this next year.)

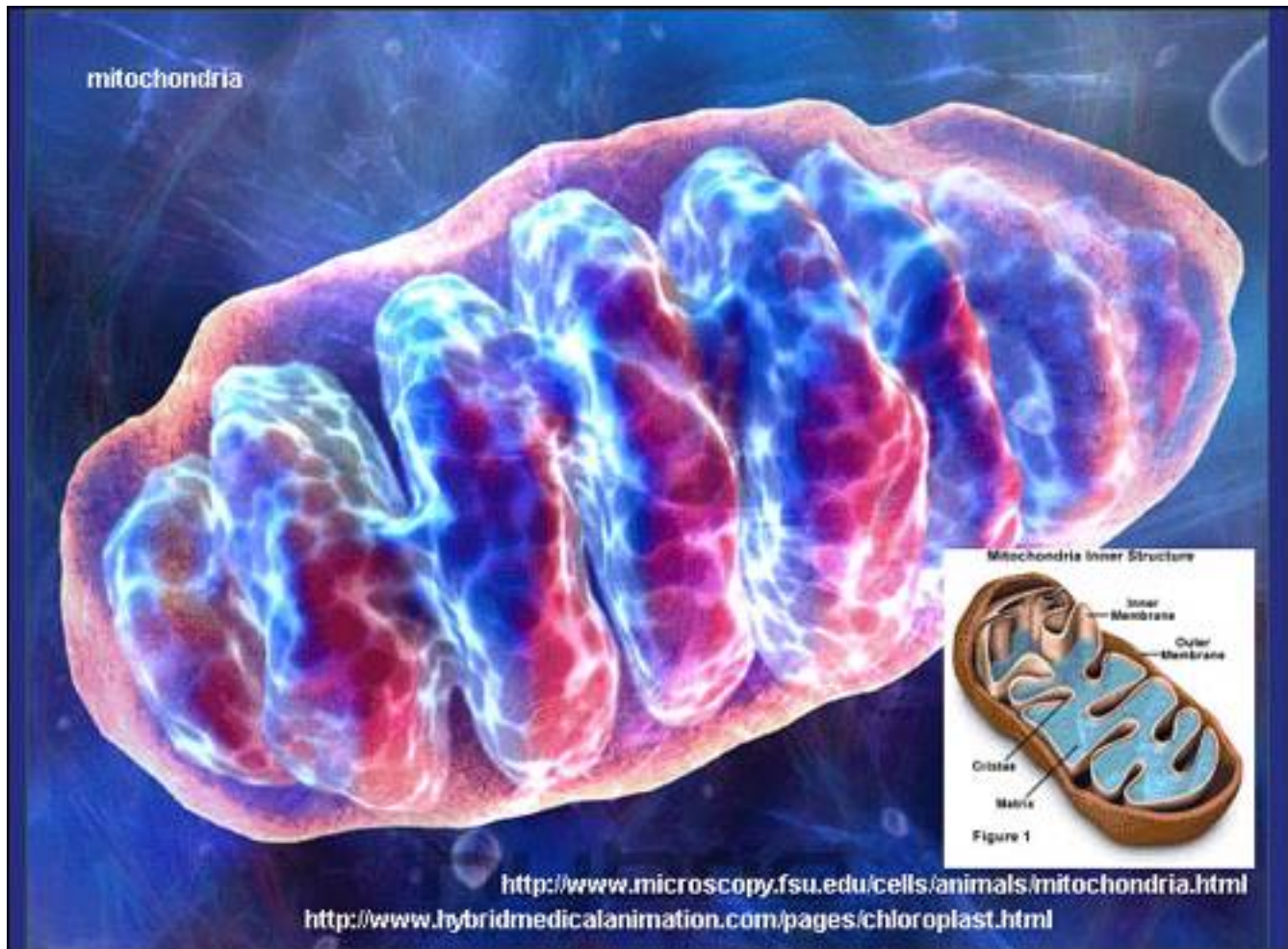
If we can't even understand the basic aspects of our own systems, what makes anybody think we can understand natural phenomena, that are thousands of times more complicated?

Because they are. Let's take a little tour of some natural complexity.

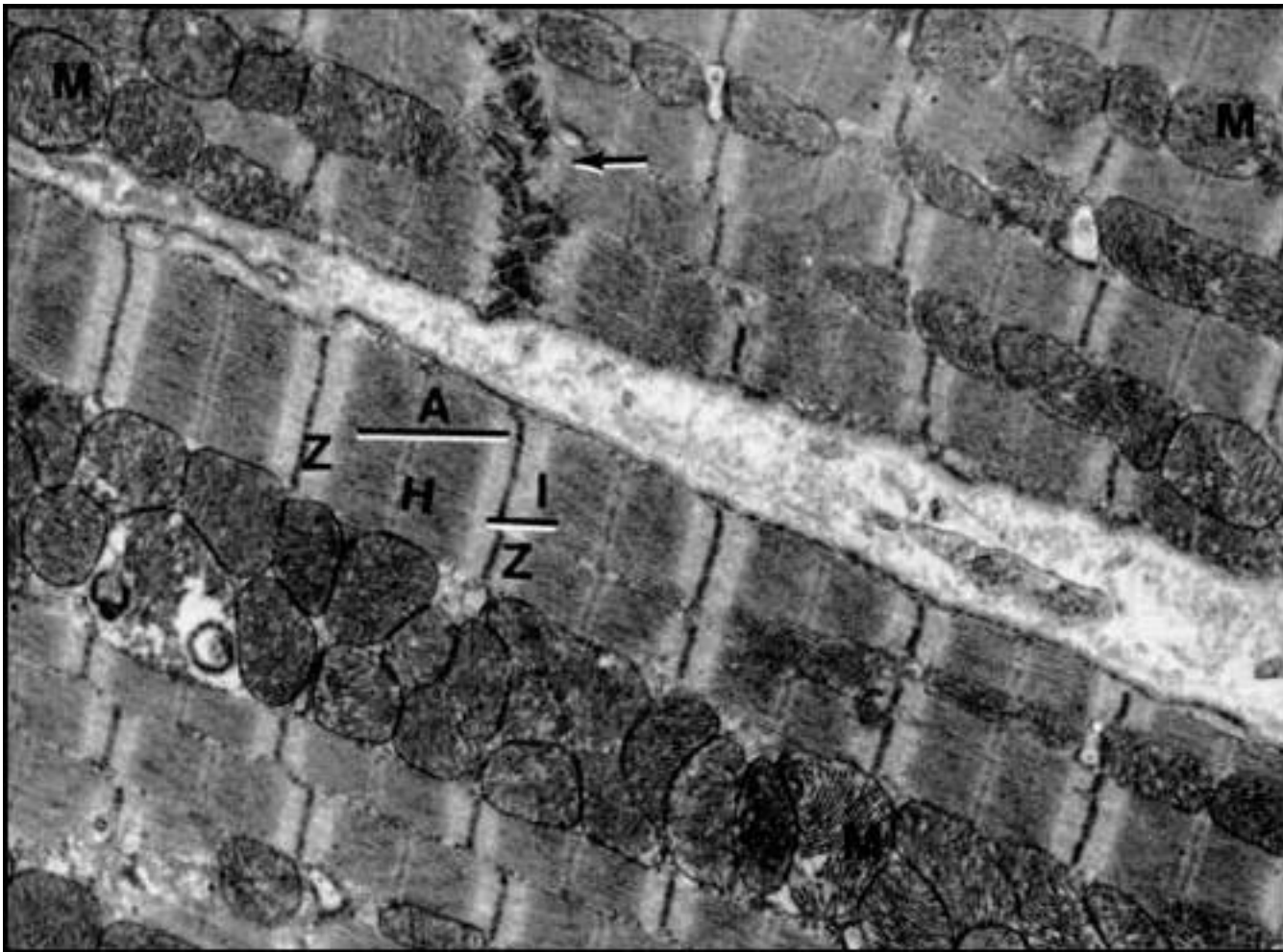
Here is a sequence of chemical changes, the ATP cascade, that produces energy within the cell. As you see, one chemical chain reaction is more complex than the original diagram showing the whole world.



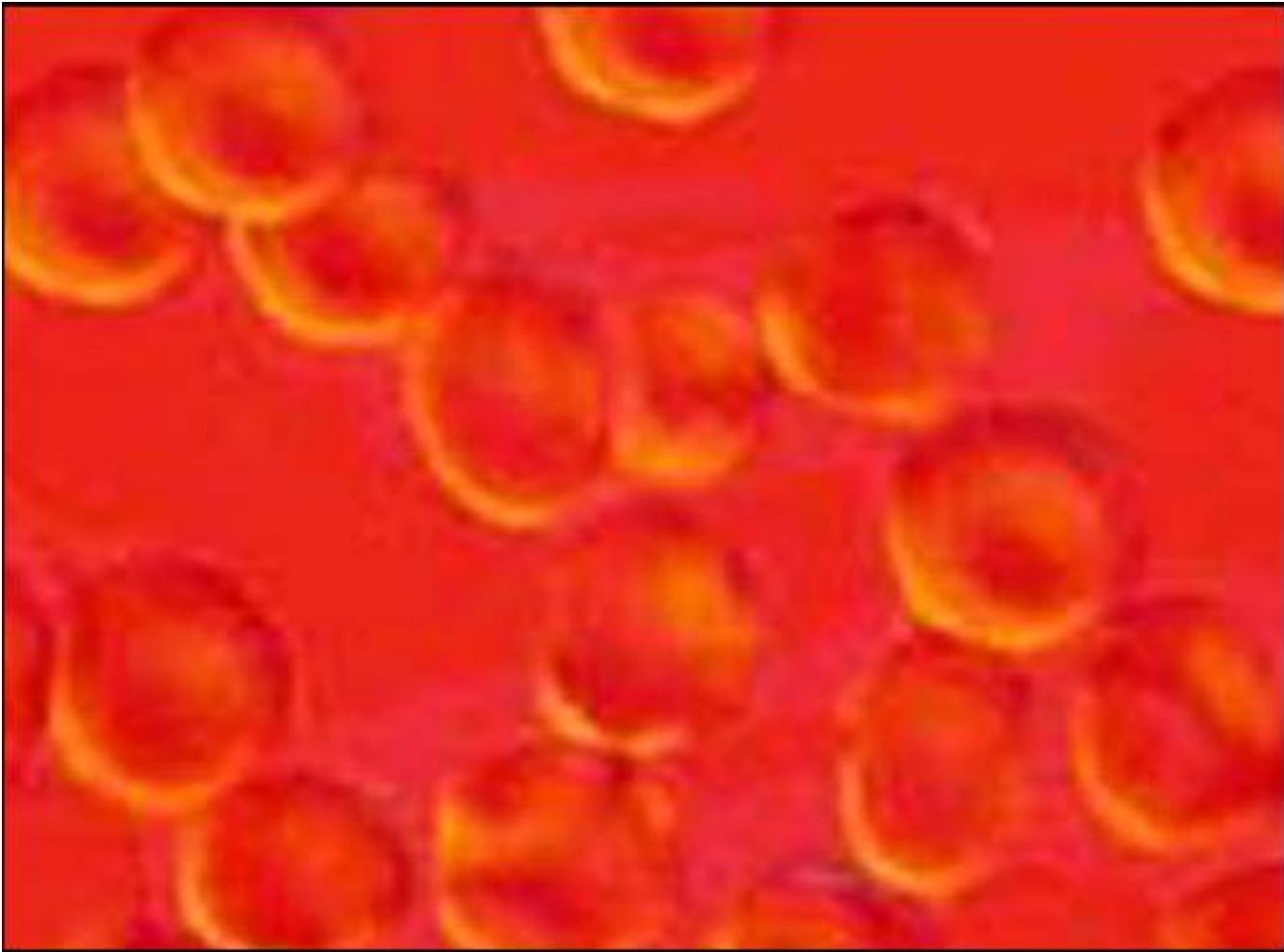
It has a complicated three-dimensional structure:



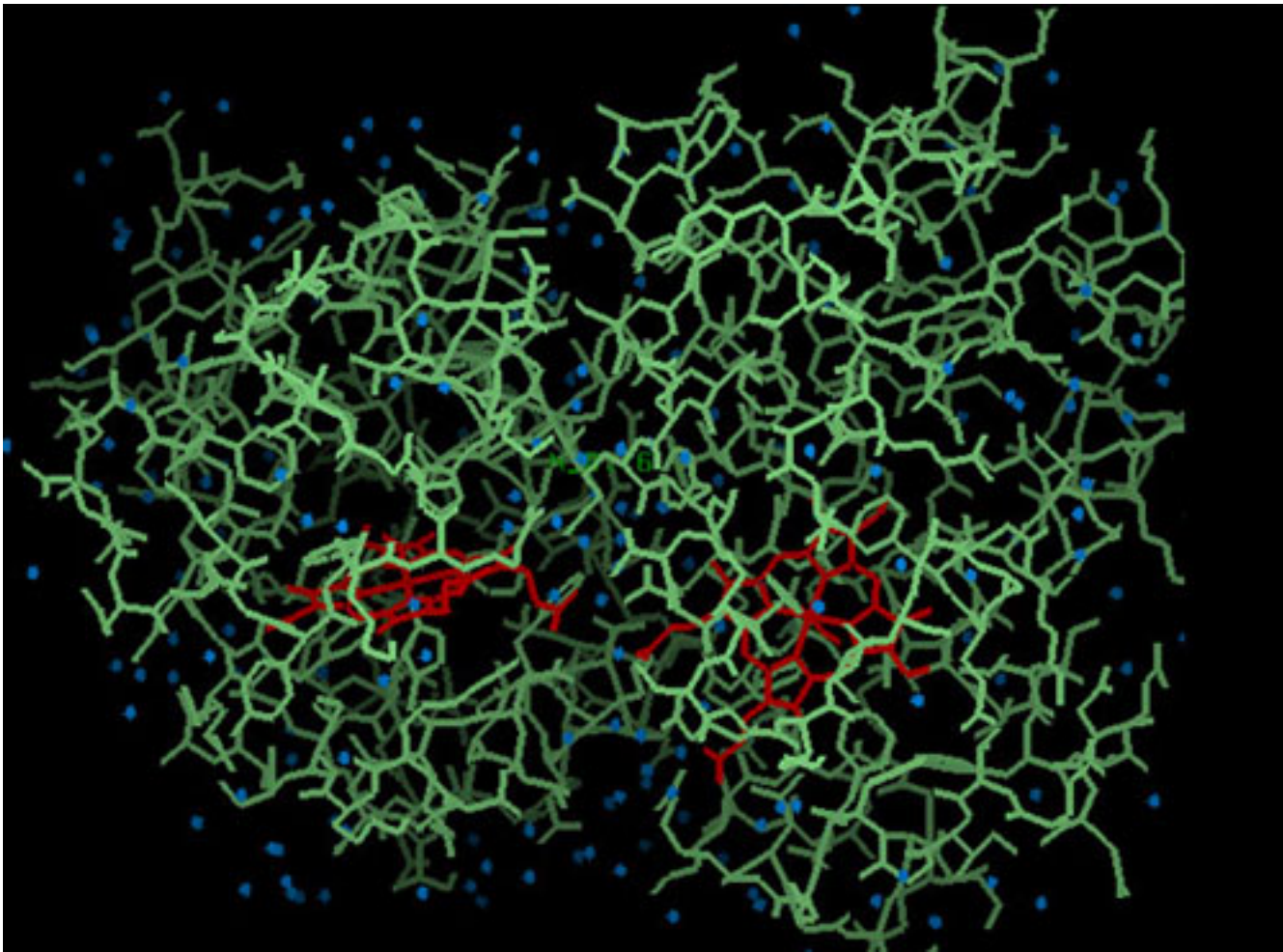
and here you see the mitochondria packed in heart muscle, where they generate energy needed for our hearts.



The heart pumps blood

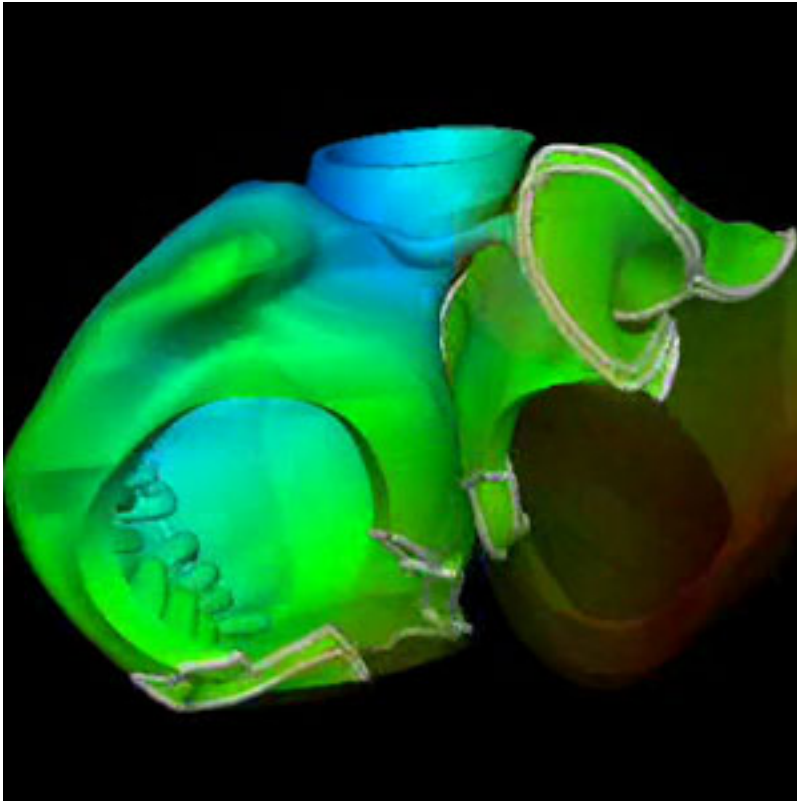
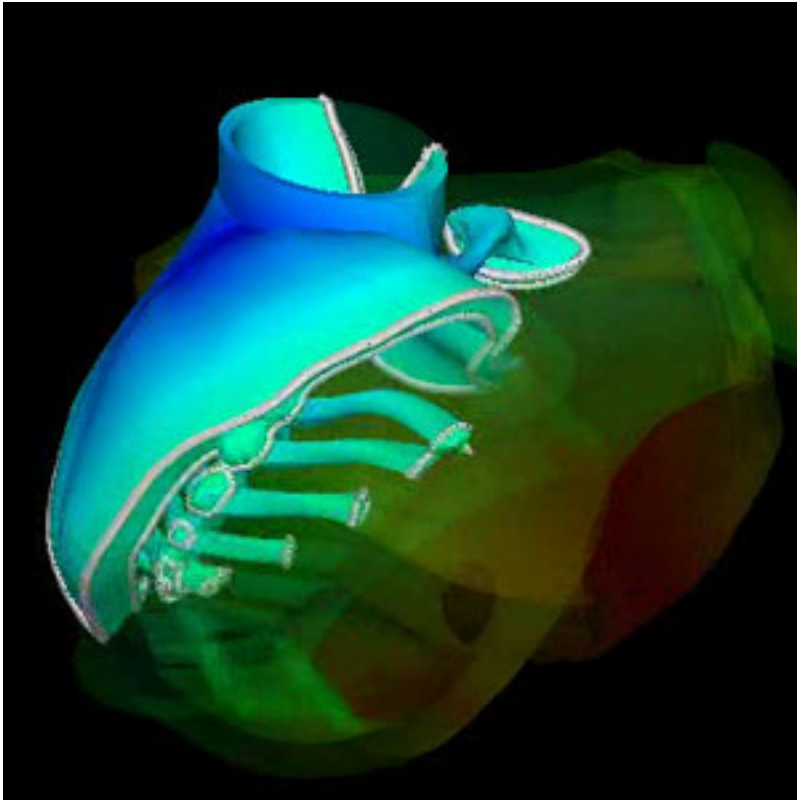


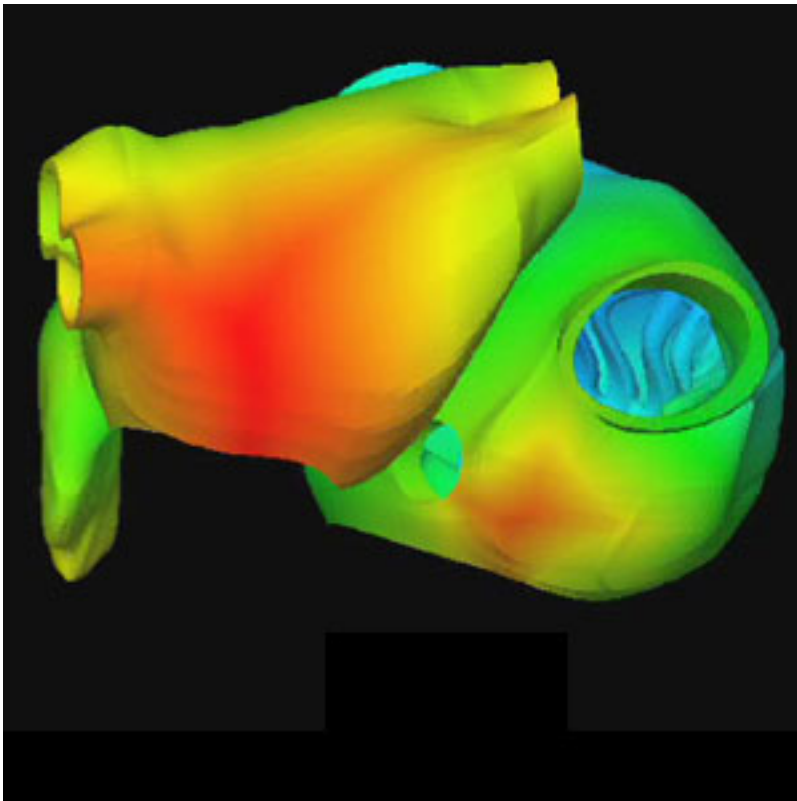
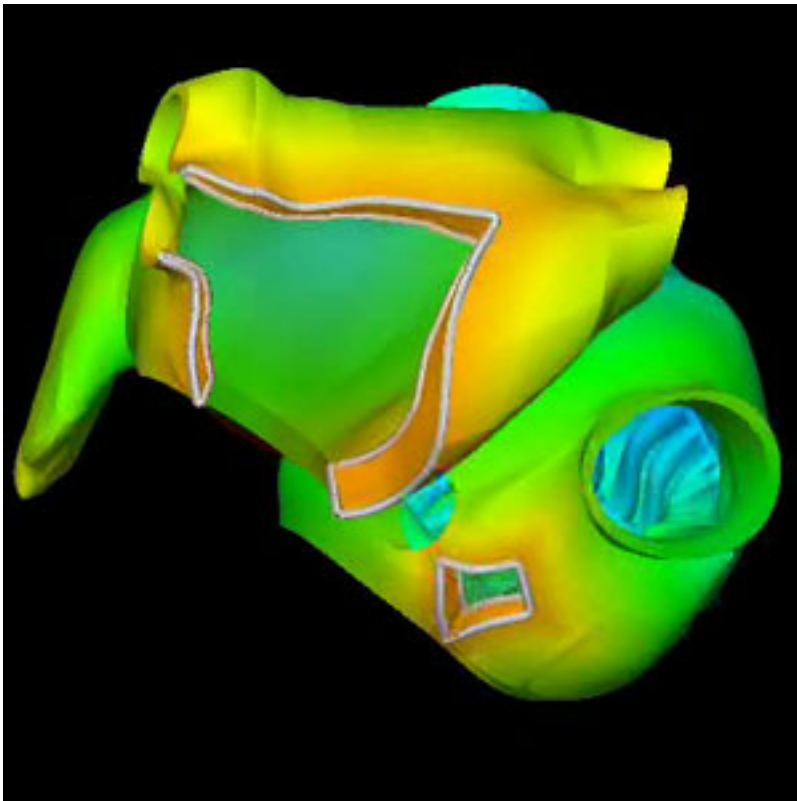
and inside the red cells there is a molecule called hemoglobin



which, as you see, is far more complicated than the original drawing of everything. A single molecule in a single cell is vastly more complicated than that drawing of the whole world.

The heart that pumps these red cells is driven by an electrical potential that spreads across the muscle in a very complex way—a way that is now understood with the help of complexity theory. Here is a conventional image





The conception of natural processes that is demonstrated in this video is precisely what has been missing from environmental thinking. Thirty years later, it's time for environmentalists to catch up. Stop worrying about decarbonization, which is taking care of itself, and start worrying about Yellowstone, which isn't.

So, in conclusion: What happened at Yellowstone? I would say, somebody really believed the world operated like this schematic diagram. And they acted on that belief.



Because the diagram implies that things are simple: Kill the wolves, and save the elk. Move the grizzlies, and avoid the lawyers. And on, and on. It's this simplistic, cause-and-effect thinking that must go.

And for that matter, who believes that the complex system of our atmosphere behaves in such a simple and predictable way that if we reduce one component, carbon dioxide, we will therefore reliably reduce temperature? CO₂ is not like an accelerator on a car. It's not linear (and by the way, neither is a car accelerator.) And furthermore, who believes that the climate can be stabilized when it has never been stable throughout the earth's history? We can only entertain such an idea if we don't really understand what a complex system is. We're like the blonde who returned the scarf because it was too tight. We don't get it.

Fortunately, studies show that we can learn to manage complex systems. There are people who have investigated complex systems management, and know how to do it. But

it demands humility.

And I would add, along with humility, managing complex systems also demands the ability to admit we are wrong, and to change course. If you manage a complex system you will frequently, if not always, be wrong. You have to backtrack. You have to acknowledge error. You've probably learned that with your children. Or, if you don't have children, with your bosses.

And one other thing. If we want to manage complexity, we must eliminate fear. Fear may draw a television audience. It may generate cash for an advocacy group. It may support the legal profession. But fear paralyzes us. It freezes us. And we need to be flexible in our responses, as we move into a new era of managing complexity. So we have to stop responding to fear:

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The future of the Earth: Is this the end of the world?

Earthquakes. Hurricanes. Floods. What is happening to our planet?

Published: 16 October 2005

Is this the end of the world? The earth shakes in Asia and a generation of children is lost. The wind flails America and a city is destroyed. A giant wave rises in the Indian Ocean and whole islands are drowned along with swathes of coastland.

The sea is turning to acid, the air is choking us, the polar ice caps are melting. Famine, pestilence and plague used to be dread words from the Bible; now they are warnings for a menacing future. But for thousands to escape, escape the globe, killing millions of

Is this really the end of the world? Earthquakes, hurricanes, floods?

No, we simply live on an active planet. Earthquakes are continuous, a million and a half of them every year, or three every minute. A Richter 5 quake every six hours, a major

quake every 3 weeks. A quake as destructive as the one in Pakistan every 8 months. It's nothing new, it's right on schedule.

At any moment there are 1,500 electrical storms on the planet. A tornado touches down every six hours. We have ninety hurricanes a year, or one every four days. Again, right on schedule. Violent, disruptive, chaotic activity is a constant feature of our globe.

Is this the end of the world? No: this *is* the world.

It's time we knew it.

Thank you very much.

Credits for Fear, Complexity, Environmental Management in the 21st Century

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