Growth: Real and Spurious

Chapter Eight from the book:

Living Within Limits
Ecology, Economics, and Population Taboos

by Garrett Hardin

ISBN 0-19-507811-X

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www.oup.com

Ordering information:
http://www.oup.com/us/catalog/general/subject/LifeSciences/Ecology/?view=usa&ci=9780195093858

Transcription and proof by Jerry McManus
Edited for the web by Fred Elbel

Growth: Real and Spurious

One of the Rothschilds is credited with saying that "Compound interest is the eighth wonder of the world." How so? Because interest makes money *grow*, supposedly *without limit*. Ecologists regard the claim as arrant nonsense, for it implies a denial of Epicurean conservation.

Like putative records of lifeless money in savings banks, real populations of living organisms grow by compound interest, but this biological reality does not move scientists to reverence. Biologists know that the growth of animals or plants does not violate conservation principles; biological growth merely involves the transfer of matter from the nonliving world to the living. Though new arrangements of matter -- new chemical molecules -- are created, the quantity of matter/energy remains the same.

Before delving deeper into population theory (the topic of the next chapter) we need to see what scientific sense can be made of growth phenomena in the world of finance. In developing the argument there will be quite a bit of manipulation of numbers, but no great precision in numbers is called for. The conclusions reached will be *robust*, a curious academic word that means that the illustrative data can be varied over quite a wide range of values without affecting the *practical* conclusions.

Growing Rich by Sitting Tight

To accept compound interest at face value is to be confronted with an apparent creation of wealth. A bank account earning 5 percent compound interest per year doubles in value every 14 years. Let us indicate the initial deposit by *D* and time (in units of l4 years) by *t*. (For instance, when the number of years is 28, $t = 2$.) The value of the account at the end of time *t* is given by a simple equation:

$$\text{Value} = D \times 2^{t}$$

Since time (*t*) is written as an exponent of the number 2 we speak of this as an exponential equation and say that the value of the account grows *exponentially*. (There are other ways of representing the growth function, but they too involve exponents.)[1]

Figure 8-l is a graph of the exponential growth of a bank account that draws compound interest. Note that the curve becomes ever steeper with the passage of I time. This is not the sort of thing we expect of natural processes, which run down after awhile. After a few decades of living the strength of human muscles diminishes, memory becomes less reliable, and vigor fades. By contrast a bank account, growing exponentially, increases at the same *relative* rate (say, 5 percent per annum) year after year, and at an ever-increasing *absolute* rate. (One year's 5 percent increase of $100 is $5; by the time the account has grown to $1,000 a year's increase is $50.) No wonder Mr. Rothschild said that compound interest (exponential growth) was a thing to marvel at.

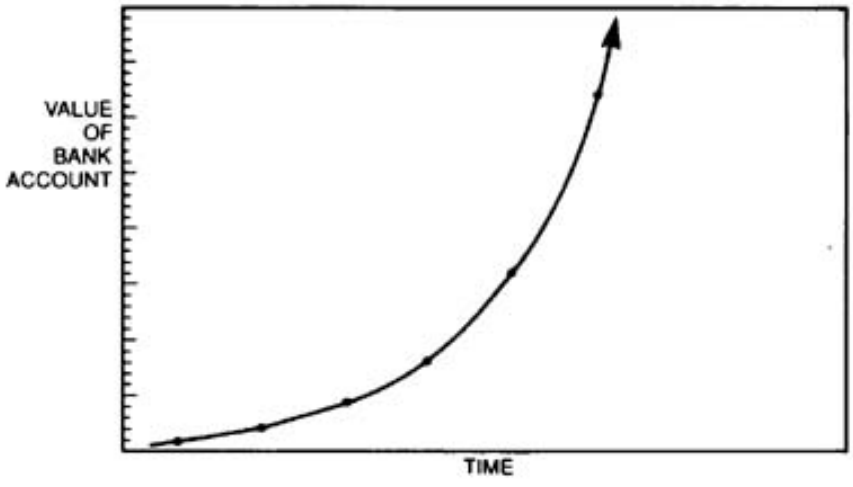

Figure 8-1. The value of a bank account that draws compound interest, showing the nature of exponential growth. With the passage of time the curve rises ever more steeply.

In the early years of a savings account the increase may not justify making the sacrifice of locking money away instead of spending it. As time goes on, however, the rewards for self-denial become greater. By influencing the distribution of rewards in society, compound interest selectively confers power on those who are capable of postponing gratification. Compound interest favors people who take the long view. (Sometimes the ones who are favored are merely those who were lucky enough to have had ancestors who took the long view.) Postponement of gratification is rewarded: does this mean that the longer the postponement the better? Let's see what happens when the time involved is great.

In chapter 27 of the book of Matthew we are told that when Judas regretted betraying Jesus for thirty pieces of silver, he brought the money to the chief priests saying, "I have sinned," and cast down the pieces of silver as he left the temple. At that point the booty became the priests' problem. They decided that since the coins were "the price of blood" they should not be added to the holy treasury. "And," verse 7 tells us, "they took counsel, and bought with them the potter's field, to bury strangers in."

Not a bad solution to an embarrassing problem. But suppose some rambling Rothschild had persuaded the priests that they should "make their money grow" so the temple would be able to do more good at a later date? Had this happened, Matthew 27 might have been written along the following lines:

> Taking counsel with certain wise men called economists, the priests converted the thirty pieces of silver into gold, which they used to open up an account in the People's Perpetual Gold Bank of Jerusalem, saying, "Let this wealth purify itself by quietly drawing interest at 5 percent per year for two thousand years. Then let both principal and interest be withdrawn from the bank and divided among all the people then living who regret the death of Jesus."

Gold and silver fluctuate in price. Let's suppose that the original thirty pieces of silver were equivalent to two grams of gold, which the priests deposited in the bank. That's about one-fourteenth the weight that could be carried in a one-ounce letter. Not much, you may say: but watch the account grow! Presumably those who regret the death of Jesus would include both Jews and Christians, who comprise about 20

percent of the world's people. (Statistics on religious affiliation are not very reliable.) For simplicity, let's assume that the population of the earth has fallen back to five billion by Regretters Pay Day, 2026 A.D. That would produce about one billion claimants to the account. On that wondrous day, how much would each beneficiary receive from the People's Perpetual Gold Bank?

At 5 percent compound interest the total sum would, in two thousand years, grow to the equivalent of 4.78×10^{42} grams of gold. How great a mass is that? The earth has a mass of only 5.983×10^{27} grams. Very little of that mass is gold, but let's suppose that it all could, by the magic of nuclear chemistry, be converted into gold. To pay off the beneficiaries, the Jerusalem bank would have to remove from its vaults 8×10^{14} solid gold earths. (That's 800 trillion earths made of solid gold.) With a billion petitioners to be paid, *each one* should receive 800,000 solid gold earths. If advance news of the payoffs persuaded *all* the earth's people suddenly to regret the death of Jesus, every man, woman, and child would be entitled to only (!) 160,000 earth-masses of gold. Where are the vaults that could store so great a quantity? Not on this earth, certainly.

The Gift of Graphing

According to an ancient Chinese proverb, "A picture is worth a thousand words." Whether this is true or not depends on what you are trying to accomplish with the picture. Some pictures are superbly adapted to the mobilization of passion. Colored pictures are good; moving colored pictures are better; and sound-augmented, moving, colored pictures are the most effective of all.

Pictures are splendid for dealing with the surface of things; but when we want to get to the deeper reality a picture may mislead us. For instance: a picture of a man shooting an elephant may make us indignantly try to stop the shooting of elephants everywhere. But what if the elephant threatened with shooting is so unfortunate as to live in a region where there are too many elephants for the food supply? Which is the crueler experience for an elephant -- being shot and dying instantly or dying slowly of starvation? A picture neither asks nor answers the deeper question.

Realistic pictures are often *ambiguous* -- or, in Latin, "driving (our thoughts) both ways." (The man photographed shooting an elephant might be a heartless sadist or he might be a tender-hearted animal lover.) Advertisers, publicists, and rabble-rousers love pictures precisely because they discourage critical thinking.

Advocates are seldom disturbed by the fact that a picture worth a thousand words may require 10,000 words to validate it.

There is another kind of picture that pays less attention to the surface of things as it plunges to a deeper reality. This is the graph. Dealing with the problem of an interest-bearing bank account a graph comes closer to picturing reality than a photograph can. (How could a camera depict 800,000 earth-masses of gold?) Where processes taking place over time are concerned, a static photograph is not as good as a graph (like Figure 8- 1). Though in fact static, a graph can be a visual metaphor for change.[2]

Humanity has not always had graphs at its disposal. The acceptance of this advance, like all social change, suffers from inertia. Millions of people have not yet learned to make use of graphs in thinking about processes. In our day gadgetry is more quickly accepted than ideas. It took only a decade for society to make room for xerography, video

recorders, and word processors. The acceptance of intellectual concepts is generally slower. For instance: in the seventh century a bundle of mathematical ideas from India -- so-called Arabic numerals, plus zero, plus negative numbers -- migrated into the Western world. Not until the seventeenth century were these inventions widely accepted -- *a thousand years' delay*.

The idea of graphing, closely related to mathematics, also took a lot of getting used to. Graphs were unknown to the ancients. The origins are obscure, but graphing seems to have been first brought to a recognizably modern form by Nicholas Oresme (circa 1325-1382), bishop, economist, and scientist. Mathematicians and natural scientists adopted graphing early, but scholars in other disciplines did so more slowly. More than four centuries after Oresme's discovery Malthus did not use a single graph. (The job of explaining population dynamics would have been made much easier if he had.) Economists in general did not take up graphing until well into the nineteenth century -- *five hundred years' delay*.

Today's financial journals use graphs lavishly; general newspapers, sparingly; and literary quarterlies not at all. Producers of the third class of publications seem to be literate only; other publishers are also numerate.[3] Those who write what they hope will be popular accounts of science face a dilemma. Undoubtedly graphs can make exposition clearer and more powerful, but the final copy has to pass inspection by the gatekeepers of the written word, who are generally non-numerate literary critics. The gatekeepers are likely to rebel at being asked to broaden their education in a direction they have sedulously avoided most of their lives. To save face, they give the numerate or graph-rich book an unfavorable review.[4] Thus is the fissure between the two cultures perpetuated.

The propagation of knowledge is roiled by conflicting interests. A writer wants to be read, but he wants also to be understood; the critic wants to save face; the potential reader wants an easy education. The balance of interests usually counsels leaving out the math and the graphs *for the present*. But the prudent present has a nasty way of extending itself into cowardly centuries. Should writers not, at their financial peril, now and then give some weight to the *long-run* interests of society?

In the technological future a nation in which graphing is second nature among the majority of its citizens will unquestionably have an advantage over nations controlled by mere words and questionable photographs.[5]

Exponential Growth: Out of This World

When we became aware of the magnitude of the hypothetical bank account maintained in the People's Perpetual Gold Bank of Jerusalem we asked: where are the vaults that could store so great a quantity of gold? To which the answer was, "Certainly not on earth." It follows from this that Figure 8-l needs revision; by simply ending the upward sweeping line below the upper border of the enclosing frame that graph is, at best, silent as to the reach of money-at-interest. Figure 8-2 comes closer to graphing reality.

Since we cannot possibly find billions of earth-masses of gold in or on the earth to satisfy the demands of long continued compound interest, we must -- contradicting Mr. Rothschild -- say that compound interest is not one of the wonders *of* the world; it is a wonder *out of this world*. That is why the line in our revised presentation, Figure 8-2, breaks through the confining rectangle of the figure as it soars off "towards infinity."

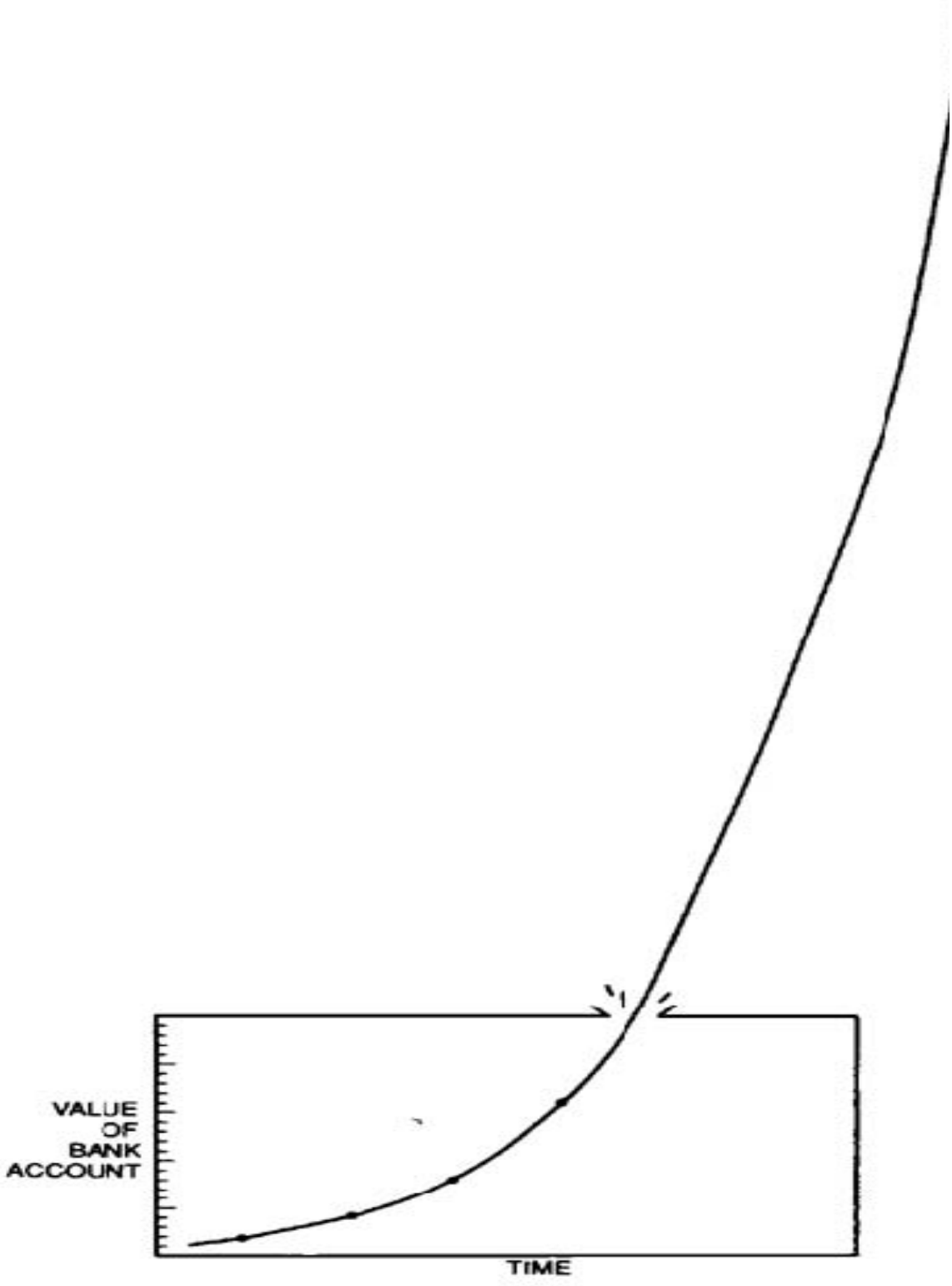

Figure 8-2. Showing how the exponential growth of a bank account at compound interest will, if` indefinitely continued, break through all limits.

This violation of the tradition of graph-printing needs to be justified. Why has the reader never seen a graph like Figure 8-2 before? One reason is that reproducing such an iconoclastic figure in a book presents special problems for the publisher. (It is only human to take the easy way out.) But I think there is a deeper reason: Freudian *denial*. Two centuries ago there was a widespread belief in providence, an extra-terrestrial force that somehow (sometimes) took care of the human species. We no longer hear much of providence, but the hunger to be taken care of remains. The interest on capital -*usury*, to use the older, more inclusive term -- seems to be a providential caretaker (of the lender at least). Mathematics and graphs that imply an adverse criticism of money-at-interest are apt to be ignored, that is, denied.

Fertile Absurdities as a Probe for Truth

Substantive wealth such as gold does not increase with the passage of time, contrary to expectations created in our minds by the institution of money-at-interest. This point was made above by creating a scenario with an absurd ending: a worldly bank account worth 800 trillion solid gold earths. Denial defends its position: "That's an absurdity! Therefore I will pay no attention to the logical point you have just made."

Reason responds: Like it or not, the conclusion is logically true. If the scenario was an absurdity, it was a *fertile absurdity*, an attention-getting way of showing the idiocy of the assumptions. The ability of numeracy to uncover fertile absurdities is one of the reasons for importing numeracy into expository writing.

Unfortunately a device that compels attention may also sidetrack it. We see this in public reactions to the work of a humorist like Art Buchwald. Now and then he discusses an injustice about which he feels keenly, but even then he uses a light, bantering touch. This is a necessary concession to the typical reader, who does not want his equanimity disturbed. The technique of the humorist is necessarily ambivalent. He needs humor to get past the reader's defenses, but then he runs the risk that his audience may say, "Oh, he's just being funny!"

A fertile absurdity relies on monstrous figures to get attention, but their very monstrosity may cause the conclusion to be dismissed. At a second stage we need to show that the conclusion does not depend on the magnitude of the figures. Nor does it depend on precise figures: the conclusion is, as we have said before, *robust*. Even the slightest increase in the paper value of money-at-interest creates an intellectual problem; for, in human experience, there is no spontaneous generation of matter. So let us suppose that the priests, having second thoughts about the safety of their funds, told the manager of the gold bank that they wanted to close out their account a year after Christ was crucified.

"Certainly," says the manager, "Here are your two grams of gold."

"But," protests a priest, "you promised us that you would pay 5 percent interest. Where's the additional tenth of a gram of gold?"

"What additional tenth of a gram are you talking about? We put your gold in the safe and there it stayed for 365 days. That's what I have just taken out and returned to you. Are you telling me that gold can have pups? Gold doesn't breed. It just sits. Take your two grams and scram!"

Dead matter does not breed. ("Breeding" does take place in some atomic reactors, but, though the term has a certain aptness, the breeding in a reactor is quite another phenomenon, and has no bearing on the points made here.) It is a great wonder that the human mind should ever have conceived such a thing as compound interest,

unthinkingly assuming that interest is capable of compelling dead matter -- gold or whatever -- to breed like rabbits.

Aristotle knew better: "Money is sterile," he said. Yet during the past thousand years we have built a civilization on the seldom questioned assumption that money is fertile. "Make your money work for you!" bankers say -- meaning, "Make it breed for you." At this late date millions of people believe in the fertility of money with an ardor seldom accorded to traditional religious doctrines.

Interlude: Economic Delusions Breed Tragedy at Versailles

World War I was brought to an end by the Treaty of Versailles. At the peace meeting of national leaders one of the advisers to the British government was John Maynard Keynes, then thirty-five years old. In a vindictive mood the Allies, particularly France, were determined to make Germany pay dearly for being solely responsible (as they saw it) for the ruinous war just ended. They imposed overwhelming reparations on the defeated nation.

Keynes, one of the best economists of his day, knew that the reparations were utterly unrealistic. Germany possessed no such wealth, nor could any believable economic growth keep up with the interest being earned on the unpaid balance. Keynes calculated that by 1936, if the accumulated unpaid reparations earned 5 percent compound interest per year, the grand total still owed by Germany would be 50 percent more than the initial reparations assessed.[6] Versailles had put Germany on a perpetual treadmill. The result of the so-called peace treaty would, he wrote his father, be the "devastation of Europe." As a matter of principle he then resigned his post as a government advisor and returned home to put his thoughts into a small book.

The result, published in 1919, was *The Economic Consequences of the Peace*, surely one of the greatest polemical works ever written. "If," said Keynes, "the European Civil War is to end with France and Italy abusing their momentary victorious power to destroy Germany and Austria-Hungary now prostrate, they invite their own destruction .... "[7] It took the rest of the British citizenry almost two decades to appreciate the truth of this remark.

The People's Perpetual Gold Bank of Jerusalem presented earlier was an absurdity created for pedagogical reasons. The Treaty of Versailles was an unconscious but equal absurdity, created by men tragically unaware of the catastrophe they had set in train. Germany made some attempts at paying the reparations, but the task was hopeless. France felt cheated, and in 1923 she set up a military occupation of the Ruhr, the steel-making region of Germany. France's idea was to collect payments "in kind" at the source -- in freshly made steel. But collection on the scale called for by the treaty would never end: German workers would become slaves in fact, if not in name. The Germans rebelled, and all work stopped in the Ruhr.

Inflation was already rampant in Germany, and by November the economy had collapsed. The government repudiated the old mark, creating a new rentenmark. The economy started up again, France was left whistling for her "just desserts" and the army of occupation eventually marched back home.

Anything else? Oh, yes: the consensus of historians is that all this disorder contributed significantly to creating conditions that favored the rise of Adolf Hitler. Causation is never absolutely certain in history but it is a plausible hypothesis that the Treaty of Versailles was a major factor in causing World War II.

Two mutually reinforcing morals can be drawn from this experience. The first: vengeance can be dangerous, even fatal, for the avenger. The second: actions that rest on untruth lead to disaster. The reparations that were demanded of Germany were beyond her ability to pay; augmented by interest payments the sum grew exponentially "out of this world." But the victors wanted payment *in* this world. An exponential increase in wealth that might, without danger, have been presumed at a low level became impossible at the level called for by the treaty. The treaty was an absurdity, but not a useful one, for it bred disaster.

Default Positions in Economics

Throughout time, but particularly in the past century and a half, the progress of science has been buffeted by two crosscurrents. On the one hand, new scientific discoveries make a mockery of` old statements of impossibility. As a result, many non-scientists (but few scientists) think that *anything we can dream of we can have* (sooner or later). Cornucopists point out that there was a time when humankind could not fly or see through solid matter or identify a particular human being by the examination of a single hair follicle. Now "we" (only a few of` us, actually) can do all these things, and more. Maybe tomorrow someone will invent an anti-gravity machine or find a way to travel faster than the speed of light. Who is to say what is forever impossible? The "Who is to say?" of the cornucopists opens the mind's door to all conceivabilities.

On the other hand, beginning in the middle of the nineteenth century a quite different intuition arose among scientists, being strongest among the most capable professionals. This was the belief that there is a small number of very broad impossibilities within whose confines possibilities have their being. The impossibilities are commonly expressed as "conservation laws," which refer to elements that are so fundamental that neither creation nor destruction affects them. Conservation laws define the default positions of science and place the burden of proof on those who deny these positions. "No free lunch" is a major default position of economics.

Many non-scientists, nurtured on science fiction, which they take too seriously, are repelled by the thought of impossibilities. This is not the view of scientists. Their gut feeling is that "only if some things are impossible can other things be."[8] (If 2 + 2 could equal either 3, 4, or 5, a trustworthy arithmetic would be impossible.) Scientists believe ultimately in real limits, however difficult it may be to nail them down in words that will be forever valid.

Games People Play: Usury

The sixteenth-century essayist Michel de Montaigne lived out his life before the great acceleration in scientific progress began. In a largely pre-scientific world it is only common sense to hold, as Montaigne did, that "No man profiteth but by the loss of others." If a man who deposits two grams of gold in a savings bank later

collects 2.1 grams it can only be because someone (the banker, perhaps) is now 0.1 gram of gold the poorer. Material wealth is "conserved," as physicists say. In the mid-twentieth century such transactions were labeled "zero-sum games." We can visualize what happens in a zero-sum transaction between two people, say Tom and Jerry. (The left side of the equation below represents the situation *before*, while the situation *after* is on the right.)

(before)	(after)
Tom + Jerry =	(Tom + 3) + (Jerry - 3)

As Montaigne might express the change, "It was Jerry's loss of 3 units of wealth that gave Tom his profit of 3 units." A modern scientist would say: "In the universe defined by Tom + Jerry, the units are *conserved*." Perhaps this becomes more obvious when we rewrite the equation in the following form:

(Tom + 3) + (Jerry - 3) = (Tom + Jerry) + O

Now we see where the name "zero-sum game" comes from. Wealth, in a two-member, Montaignesque, system, is conserved. The sum of personal gains is matched by the sum of personal losses. In the transaction, the whole system gains exactly *zero*. A winner may view the result as no more than he deserves, while the loser may complain, "Unfair!" But what say the bystanders?

However various the religions of the world are, most of them try to imbue their followers with a love of fair play. In a non-growing society (with unavoidable "frictional" losses due to decay, and so on) there are more human losers than human winners. (There are more paupers than millionaires.) In such a world, taking the part of the losers is a promising path to political power. With personal and institutional power to gain it is no wonder that, early on, religious leaders condemned the lending of money at interest, no matter how small. They called the practice "usury." For a long time after the death of Christ usury had no defenders in the Christian community. There is no documented reason to think that primeval religious leaders had a profound understanding of the ultimate consequences of exponential growth. Love of fair play was sufficient reason for condemning a usurious banking system.

Nature is Added to the Game

It was not until the thirteenth century that Christian leaders began to find a justification for charging "moderate" interest. At this point usury was redefined as the charging of "excessive" interest. Anyone who distinguishes between "normal" and "excessive" in deciding what is permissible and what is forbidden is practicing what Joseph Fletcher calls "situation ethics."[9] (Note that the Ten Commandments, and most traditional religious-ethical proscriptions, are not stated in situational terms. This is their fatal weakness.) For simplicity, and to avoid arguments about the point at which interest begins to be "excessive," the rest of this discussion will use the old- fashioned term "usury" for *all* positive rates of interest.

Usury was first permitted on a tribalistic basis: it was permissible for Jews to charge Gentiles interest, and for Gentiles to charge Jews. Even today, devout Moslems who refuse to exact interest from fellow religionists are quite willing to invest their oil revenues in interest-bearing financial instruments of the non-Moslem world. In

such an arrangement the conscience of the lender is spared by an inbuilt discrimination made between *brothers* and *others*. The parochialism of *Us* versus *Them* is older than catholicity. Loyalty to *Us* forbids profiting from losses imposed on brothers; losses sustained by *Others* can be accepted with cheerful indifference.[10] With the passage of time the sheer growth of population makes it easier to view almost all people as "others." Once that shift is made, it is easy to accept universalized usury.

Why should a borrower consent to the charging of usury? The motivations of borrowers and lenders are significantly different. The lender hopes to increase his wealth (though of course he will have to wait awhile for the gain). The borrower on the other hand wants his pleasure now. Perhaps he wants a new sofa. The psychological gain from early comfort may more than balance the loss caused by working longer hours to discharge the accumulating debt. The interest extracted from the borrower is the cost he pays for his impatience.

There is another reason why usury has become more popular since the thirteenth century. With the passage of the centuries "nature" has increasingly been dealt into the game of human life. In its simplest form, the game now has three participants. As a representative transaction consider the following case. Tom borrows a sum of money from Jerry, which he uses to buy some mining equipment. With this equipment he digs ore out of the ground and sells it for enough money to pay off his debt plus interest, with a profit left over for himself. A first attempt to represent the results of this enterprise produces the following equation:

(before)	(after)
Tom + Jerry + Nature =	(Tom + 4) + (Jerry + 2) + (Nature)

The numbers arbitrarily entered into the equation above make the point that when nature is dealt into the game, both Tom and Jerry may benefit. Envy may make Jerry resent the fact that Tom's gain is greater than his, but Jerry cannot maintain that he has been cheated out of some of his wealth. Tom, of course, can claim that the reward for vigorous activity should be greater than the reward for merely passively collecting interest.

The true situation is far more complex than our equation indicates. Metal may be extracted from the ore that is mined, and the product may be fashioned into machinery for making useful things that simplify the lives of multitudes of people not formally engaged in the initial enterprise. They gain from the "trickle-down effect" of human enterprise.

In a narrow economic frame of reference, conservation *appears* not to be observed in our equation; such an appearance is always suspect. In a true Epicurean spirit we must balance the production equation so that it is an honest zero-sum game. For a long time human beings were either unaware of the role of nature in the increase in human well-being, or they thought of it as a providence-like entity that bestowed blessings-without-loss on humanity. In the late twentieth century the movement labeled "environmentalism" has corrected the historical errors in this way:

(before)	(after)
Tom + Jerry + Nature =	(Tom + 4) + (Jerry + 2) + (Nature - 6)

Thus can we formally depict the environmentalist's version of the game of life as a zero-sum game. The numbers, however, are figurative. The stated loss of (-6) suffered by nature may take many forms: loss of soil, pollution of ground water, and extinction of species are only a few of the many possible, which are seldom measured or estimated until the losses begin to hurt.

A Difference Between Economics and Ecology

Serious mistakes can be made by analysts who have difficulty seeing some of the players in the game. In the past, economists have often been blind to nature. The following example serves to illustrate the point.

The economist Peter Bauer, in an essay on Malaya (Malaysia) spoke of the "largely empty and economically backward Malaya of the nineteenth century."[11] A paragraph later Bauer again put forward the image of "emptiness" when he referred to the "hitherto empty jungle." A biologist with even the slightest experience in the field finds this imputation of emptiness nothing short of astounding. Charles Darwin would never have applied the adjective "empty" to a tropical jungle. Writing home from Brazil in 1832, he spoke ecstatically of his experiences "wandering in the sublime forests . . . surrounded by views more gorgeous than even Claude [Lorrain] ever imagined."[12] The complexity and beauty of tropical ecosystems has been a source of endless wonder to biologists from Darwin's day to the present time. It is plausibly estimated that more than half of the world's 20 to 30 million species of plants and animals live there. "Backward Malaya in the nineteenth century" had many species of plants and animals that were wiped out by the commercial "development" of the twentieth century -- "empty" indeed!

Bauer's ignorance of the tropics did not spring from a simple lack of experience. Born in Budapest, he spent most of his life in European cities (principally London), but he did have a few months' exposure to Malaysia. But when out of the city he evidently observed with city-grown eyes. To shock economists as Bauer has shocked ecologists, an animal-loving biologist would have to describe the center of New York City in some such words as these: "Except for Central Park, Manhattan is virtually an empty island."[13]

Global economics must be enriched to include nature in the equations that show the exchanges taking place among human beings. As used by economists, the exchange equation takes this form:

$$\text{Tom} + \text{Jerry} = (\text{Tom} + a) + (\text{Jerry} + b)$$

If $a - b = 0$, the equation is balanced; this is a zero-sum game.

If $a - b =$ a positive number, the game is a positive-sum game and an economist has no hesitation in saying that "wealth has been created." This, of course, contradicts the economist's usual claim that there are no free lunches.

Following World War II the rich countries of the world, for complex reasons we need not go into here, dedicated some of their wealth to the "development" of the poor countries of the world. Unfortunately, enthusiasm outran knowledge. Agencies like the World Bank, with many billions of dollars at their disposal, were advised almost entirely by ecology-ignorant, city-bred economists like P. T. Bauer. The results have, not

surprisingly, been all too often unfortunate for the objects of their interventions, the poor people themselves. If an environment is perceived as "empty" until the developmental economist rides up on his white horse, God help the environment![14] (And God help the poor!)

Ecologists, like other scientists, regard the assertion that wealth has been created as evidence of a serious defect in the plus-sum equation, precisely because it violates conservation. Ecologists insist on putting nature into the picture:

Tom + Jerry + Nature = (Tom + a) + (Jerry + b) + [nature - (a + b)]

What people have taken from nature, nature has lost. Thus is conservation observed when economics is wedded to ecology.

Naturally those who have been trained in traditional economics take exception to the new equation. They fear that acknowledging the contributions of nature to human wealth may lead to demands that we curb the rate at which we appropriate nature's wealth. Their main objections are two. The first is the classic one voiced two centuries ago by the American artist John Trumbull in response to the demand that he do something for posterity: "What has posterity done for me?" There is no easy answer to this question, but it should be noted that if this cynical view had been that of all our ancestors, most of us wouldn't be here today.

The second objection to the conservation of nature's wealth is most often heard from types who glory in being "hard-headed." They ask: "Which is more important -- dickie-birds or human beings?"

The implied choice is fraudulent. When dickie-birds are sacrificed something of value is removed from human life. In the terrible days after the Chinese revolution of 1949 the poverty was so great that the people killed almost all the birds and ate them. Understandably, each person decided that his life was more important than the lives of the birds around him. What they were blind to was the total ecosystem of which both human beings and birds were but parts. Killing insect-eating birds subsequently caused an increase in the number of insect pests that competed with people for food. The Chinese learned the hard way that dickie-birds do matter.

Though they did not know it, the Chinese were choosing between two worlds: [a world with human beings *plus* birds] and [a world with human beings *minus* birds.] Even if we grant the hypothesis that the number of human beings would be greater in the second case it is not a foregone conclusion which world we should strive for. ls the total value of human life greatest when the quantity of *human* lives is greatest, if the *quality* of life is poorer for all individuals? The answer is not obvious.

The policy choice is *not* [man *or* nature], but [man *with* nature] versus [man without nature]. City dwellers whose experience with natural things is minimal may express no interest in nature; but those whose experience has given them an appreciation of the enrichment of human life by other kinds of life will grant the wisdom of opposing the uncontrolled destruction of natural wealth. Conservation of the environment in this generation enriches the lives of subsequent generations.

When "nature" is left out of a written equation, the *before and after* change looks like the magical creation of wealth. Since human beings are involved in this magic, economists (and others) who are satisfied with nature-

free equations develop a dangerous hubris about the potency of our species. The hubris is built into the GNP (gross national product), a statistic that has, since 1942, been quoted every day in financial reports. While taking account of the exchanges of money between the Toms and Jerrys of the nation, the GNP is blind to what happens to natural resources. All the exchanges of money incident to pumping oil out of the ground and burning it in automobiles increase the GNP, but the fact that the oil, once burned, is lost forever to the wealth of the nation receives no notice in the GNP. Similarly the loss of healthy, breathable air is not noted -- except for the *increase* in GNP caused by the money that is spent for pollution control equipment on automobiles as well as the hospital bills attributable to auto-generated smog. The inconsistencies of GNP-based economics have been caustically noted by Robert Repetto (Box 8-1).[15]

Box 8-1. Devastating Defects of the GNP.

If toxic substances leak from a dump site and damage soils and aquifers, a nation's measured income does not decline. But if a government spends millions of dollars to clean up the mess, measured income goes up, because such expenditures are considered purchases of final goods and services.

If a firm undertakes the same cleanup itself income does not rise, because the expenditures are counted as part of the costs of` production. But if the site is left polluted and households incur medical expenses, income does rise: the national income accounts treat such costs as final consumption.

Roben Repetto, "Wasting Assets," 1991.

Conventional economic thinking has been dominated by the GNP for half a century. It is easy to see why the entrance of ecological thinking into economic thinking in the 1960s was so vigorously opposed. People do not give up delusions easily: an increase in GNP sometimes stands for a loss in income. Only now are some insightful economists trying to concoct a new and more honest measure of productivity that will combine the insights of economics and ecology. The task is a daunting one.

Modes of Creating Wealth

Even if wealth in the physicist's sense cannot be created, wealth in a simpler human sense can. It is worth our while to review some of the better known means of improving the human condition.

First of all, potentially useful but diffusely distributed materials can be brought together, concentrated. For several thousand years human beings have been concentrating various metals from their ores (iron, copper, and so on), thus making possible the manufacture of tools and machines, which greatly increase our ability to wrest a living from nature. We never create atoms of copper or iron, but we certainly concentrate them and rearrange them into more useful configurations.

The capture of energy follows a somewhat different course. The iron in a machine is useful for a long time, though the atoms are ultimately disassociated from one another through friction and dispersed in the environment again (from which they can be re-concentrated through the expenditure of more effort and energy). But the energy (what physicists call "negentropy") resident in coal, oil, and gas can be used only once. Such useful energy is a capital accumulation from sunshine that was absorbed by the earth millions of years ago. Once used, the capital of negentropy is gone forever.

Another way of creating human wealth is by increasing the efficiency of human efforts. Two ways of doing this are obvious: either fewer human beings are used to carry out the job, or the time taken by one human being is reduced. As an example of reducing the number of human beings used in performing a task, consider the wheelbarrow. Up until the late Middle Ages the moving of materials was often accomplished with a two-man barrow -- a platform or vessel with two shafts forward and two shafts aft.[16] One porter took the forward shafts, another the aft, and off they went.

Then some unsung genius realized that a wheel could be substituted for the forward porter, and *voila*! the work force required for the job was instantly cut in half. It is not often that a labor-saving invention cuts the input of labor by 50 percent. This advance came in what we, in our arrogance, are pleased to call the "Dark Ages."

The second way of increasing efficiency, through reduction of the time taken for the job, achieves its economic effect by virtue of a physiological truth: the calories of energy required by a human being can be divided into "maintenance calories" and "work calories." Just to stay alive, doing no useful work at all, requires about l,500 calories per person per day. A moderately active clerk requires about 2,500 calories -- 1,500 maintenance calories plus 1,000 work calories per day. A lumberjack or miner may burn 5,000 calories per day (of which 3,500 are work calories).

Since maintenance calories are burned off at the rate of about 125 calories per hour, whether any work is being done or not, any improvement that saves human time saves energy (assuming the investment of work calories is the same). This is one of the principal virtues of modern transportation. (Think of the economizing of human time in flying across the Atlantic versus taking a slow boat.)

The benefits realized from an improvement do not necessarily go to those who are responsible for the innovation. The man who drills a new oil well gets only a fraction of the gain it brings to society. Others gain from trickle-down effects. Society tries to put primary innovators in a more favorable position by supporting a patent office to give inventors monopoly rights (for a limited time). We establish such legal rights partly out of a desire to be "fair" to inventors. An equally important reason is to encourage other ingenious men and women to make more inventions in the future.

Unlimited Breeding of Debt

Does usury create wealth? What is it that breeds when a bank account grows? Gold can't breed; neither can any other valued nonliving, material thing. Though material wealth cannot breed, *debt can* -- and without limit, because its breeding is, inherently, a breeding on paper only. *Through usury we acquiesce in the breeding of debt.* When a depositor turns his gold over to a savings bank, two growth processes are set in train. The first growth process takes place in the mind of the depositor, who supposes that his cache of gold is growing in accordance with the compound interest formula (as visualized in Figure 8-2).

The locus of the second growth process is harder to specify because the process is diffusely distributed. At first glance it seems to be at the bank, perhaps in the mind of the banker who receives the deposit. But the banker is only an agent for the bank's board of directors, and these in turn act for the bank's borrowers who are required to pay back to the bank any money they may have borrowed, plus interest.

If many borrowers default on their payments, the necessity to pay the depositors devolves first, in part, on the directors, but then (more importantly, in the United States) on the FDIC (Federal Deposit Insurance Corporation). The funds of the FDIC come from thousands of member banks. If these funds are insufficient, the national treasury will be tapped, at which point the money comes from the taxpayers.

It is fair to say, then, that the locus of the growth process of debt is in the nation as a whole. The nation may

eventually be called upon to make the figures on paper match the figures in the minds of the depositors. Without inputs from outside the system, a return of capital and interest in gold is not possible, as we have seen in the story of the People's Perpetual Bank of Jerusalem. There's nothing special about gold, of course: any material substance will fail as the "standard" of a usurious banking system. The obligations of a bank, of a banker, of the bank's board, of the borrowers, or of the FDIC to convert an ideational debt into material payments may be *legally* binding; but men do not write the laws of nature. Our species can, however, increase its drafts on the bounty of nature (within limits), and the efficiency with which we exploit this bounty (again, within limits). These increases constitute what we conventionally refer to as the "creation of wealth."

As far as the earth's economy is concerned there is a daily input of wealth from the outside in the form of radiant energy from the sun. Some of this energy is captured by the earth, so terrestrial wealth should steadily increase. The captured energy takes the form of plant material (corn, wheat, wood, and so on), or the form of water vapor elevated to the clouds from which rainwater discharges into mountain streams.

Sooner or later this energetic wealth is degraded by ingestion, digestion, and metabolism; by burning; or by being converted to electricity that illuminates light bulbs which heat up rooms. The ultimate form of this changeable wealth is heat and this, finally, is radiated out into space. If the heat were not so lost, the surface of the earth would eventually become unbearably hot. Over the long term the earth's "metabolism" can be epitomized as a zero-sum game: [input of solar energy] minus [radiation of terrestrial heat into space] = zero. (There can be a lag of several hundred million years in this equilibrating process, as, for example, when oil and coal deposits were laid down and remained as dormant stores of wealth until human beings brought this wealth to the surface and burned it.)

But let us return to the evanescent affairs of our civilization. The amount of debt can approach infinity; not so with the amount of any material goods that are specified as the coin of debt. After a long period of time a bank may be unable to extract from its borrowers (and the public) enough wealth to pay off its depositors. We are ordinarily saved from perceiving the fictional nature of usury by the complexity of the banking system. The complexity can befuddle even the managers of the system. Walter B. Wriston, chairman and chief executive officer of Citibank (New York's largest commercial bank), once authored a pamphlet in which he claimed that the modern world had outgrown the need for the great banks to back up their lending with any capital whatsoever, because (he maintained) a giant bank can always borrow whatever funds it needs by floating financial instruments in the market.[17] Thus is perpetual motion invented once more, this time by "hard-headed bankers."

The shaky foundation of the theory of usury was recognized early in this century by the nuclear physicist, Frederick Soddy (who, significantly, played a key role in the development of "breeders" in nuclear physics). The portentious implications of Soddy's work for economic theory have been almost entirely ignored by economists. Always, the priests of one religion (economics, in this case) are prone to ignore anything said by the priests of another (physics). Herman Daly is one of the few economists who have appreciated the revolutionary importance of Soddy's insights.[18]

The "bottom line" of an exact analysis of compound interest reads as follows: Though the inflow of solar energy increases the wealth of the earthly system, purely terrestrial processes do not increase the material wealth of the entire globe, whether under human control or not. On the contrary, material wealth is continually being degraded to less useful forms. Only debt can grow exponentially; and the convertibility of immaterial debt to material

wealth should never be assumed.

Usury Running Wild

As we have seen, it took about a thousand years for the Arabic number system to be generally accepted by educated people. It took about five hundred years for graphing to reach a similar degree of acceptance.

Must centuries also pass before the fictional nature of exponential growth is generally recognized? Several considerations point to a pessimistic conclusion. First of all, there are some signs of the decay of education in our part of the world. Perhaps as a consequence of increasing the size of the clientele of our schools too fast the appropriateness of mathematics in general education has come under attack. The percentage of students learning algebra is falling. When we come to look at establishment members who might give voice to home truths about exponential growth, we note an unfortunate division. To the professional economists who understand the situation perfectly well it seems so boring a truism that they don't want to waste their time mentioning it. On the other hand investment counselors and the like stand to gain financially by not fully explaining the properties of exponential growth. Some of them even seem unaware that usury has no power over matter. As evidence thereof consider the following true story.[19]

In 1913 a wealthy man named Jonathan Holdeen set up a number of trusts, to run variously for five hundred to one thousand years. At maturity the benefits were to be distributed to family members and charities. At a modest 4 percent compound annual interest a bequest of $100 would amount to 33 billion dollars in five hundred years; continued for one thousand years, the accumulation in a single such account would be more than 10 quintillion dollars ($1.08 $\times 10^{19}$). And Holdeen set up 186 such accounts before dying in 1967!

When the trusts were challenged by a tax authority in 1975 most of the bequests held up in court, because (said the judge) there was no evidence that Holdeen himself benefited economically from his bequests. So far as the news report revealed, the court did not deal with the larger question, namely: What is the chance that such bequests can be paid off at maturity?

In evaluating a policy it helps to generalize a particular case to include many instances operating over an indefinite amount of time. Let us suppose that Holdeen's example was followed by others. About two million (2×10^{6}) Americans die each year. To be conservative, suppose that only 1 percent of these emulate Holdeen, each one leaving behind a single one-thousand year trust. That would be 2×10^{4} trusts to mature a thousand years later. At 4 percent interest each trust should yield 1×10^{19} dollars, or $\$2 \times 10^{23}$ for the whole bunch of trusts left by philanthropists in one year. How many Americans would be present to pay the beneficiaries of the trusts when payments became due? I don't think even the most immoderate pro-natalist would suppose that the U.S. population would be more than 2×10^{10} a thousand years from now -- which would be 20 times the present population of China.

Remember: wealth cannot breed -- only debt can breed. The Americans on deck a thousand years from now would have to find the money to pay the obligations of the Perpetual Bank. The average American would then

have to throw into the kitty 10^{13} dollars to pay off the trusts. That's 10 trillion dollars from each hapless citizen. And they could expect a similar bill the following year. And the next year.

Of course some of the same Americans would be beneficiaries under the trust deeds. Soddy's words give an apt description of such a situation: "[A]s a result of this confusion between wealth and debt we are invited to contemplate a millennium where people live on the interest of their mutual indebtedness."[20] In other words, money-at-interest, continuously operating without limit, produces a perpetual motion machine.

A judge in the Holdeen case who understood the imperatives of the default positions of science and scientific economics would have terminated the trusts pronto. A judge without this understanding would, I suppose, maintain that he is required to base his decisions on statute law only, leaving fundamental remedies to the legislature. But what if the ruling in a case depended on the assumption that the world is flat or that *pi* equals 3.0000 exactly? Sacred Hebrew documents make the second assumption.[21] What if a plaintiff in the name of religious freedom, demanded that the court accept his commitment to the Hebrew value of *pi* in judging a commercial conflict? In such a case the courts would surely not hesitate to augment the roster of legislative laws with the laws of nature, acknowledging that nature is paramount over religion. The judge in *Holdeen* should have acknowledged that it is a law of nature that unlimited exponential growth is possible only for imaginary debt and not for material wealth.
Usury fails the policy test of being extensible over many people over long periods of time. We are never told about this in any of the promotional literature of financial institutions. Nor are children told this in public schools. (For that matter, how many university economics courses treat this matter candidly?)

Some state laws, it is true, strictly limit the length of time an inactive bank account can draw interest. We may laugh at the true story of Mr. Holdeen and at the myth of the People's Perpetual Gold Bank of Jerusalem, but promoters of savings banks don't hesitate to take advantage of the public's acquisitive impulses by *implying* that there are no limits to usury. Even today there is, in the District of Columbia, a chain of banks that has the word "perpetual" in its name. No doubt its more simple-minded depositers take the word at its face value.

The Necessity of Failure

Neither the Holy Land, nor any land less holy, has ever had the stability needed for the maturing of a usurious account over a period of two thousand years. Realistically, we admit that there is no reason to think that any of the world's present sovereignties will last two thousand years. Few will last even two hundred years. Going from the unreal world of theory to the real world of contingencies we see that the potentially ruinous consequences of usury are deflected by many sorts of failure.

Item: *Bank Robbery*. At first glance this might not seem an escape from the insidious threat of usury. If the robbers turn around and reinvest their loot in interest-bearing accounts, the act of robbery merely amounts to a redistribution of debt obligations. But the temperament needed to become a successful bank robber is unlikely to include much prudence. What with one thing and another, ill-gotten gains are likely to be squandered in ways that interrupt the interest cycle.

Item: *Bank Failures*. When a bank goes belly-up, its depositors lose some or all of their principal and

interest; stockholders suffer losses, too. The community's aggregate burden of interest is lightened at the expense of some of its members. "Bad luck!" the rest of us say -- and go about our business. (At least that's the way it used to be, before the FDIC)

Item: *Market Crashes*. The paper value of stocks -- the amount that may be demanded of somebody by the holders of stock certificates -- falls dramatically in a stock market crash. The effect of this is to redistribute wealth -- *paper* wealth. It has been calculated that the Wall Street crash of 19 October 1987 caused a loss of $1 trillion.[22]

Item: *Repudiation of Debts*. After 1492, the government of Spain, spoiled by unearned riches from the New World, settled into a mode of pursuing honor-through-war, moving ever closer to national bankruptcy. In the years 1557, 1575, 1596, 1607, 1627 and 1647 -- every fifteen years on the average -the government repudiated its debts.[23] Of course, it seldom did so candidly; instead it forced its creditors to exchange "old paper" for new, which was worth less and had built-in time delays on payments. "It couldn't happen here"? Don't be silly. Any government that wages war for honor's sake is suspect. ("Honor" is all too apt to mean, "We don't know what the hell we expect from this war -- or even how to recognize victory if it dropped in our laps -- but we're committed." Denial reigns; truth suffers.)

Item: *Confiscatory Taxes*. After World War II, England, in desperate economic shape, taxed capital gains at more than 100 percent. Such taxes removed not only the year's gain but also part of the capital that made the gain possible. (This is known as "killing the goose that lays the golden egg." Prudent political counselors advise against it.)

Item: *Revolutions*. Bonds of the old imperial government of Russia were considered fine, conservative investments worldwide -- until the Communist Revolution of 1917. The new government repudiated the debts of the old, of course. The delinquent imperial bonds (which were beautifully engraved) continued to be bought and sold in the capitalist world, though at disastrously reduced prices, for another twenty years. (Faith is wonderful.)

Item: *Inflation*. This is far and away the most important of the systematic curbs on usury. It deserves a section of its own.

Inflation, the Ultimate Tamer of Usury

The general trend of economic history, albeit with many interruptions, is inflationary. Americans often complain of inflation, but they have never experienced more than the opening stages of the process. Our limited experience inclines us to make light of the danger of truly runaway inflation ("hyperinflation"). Perhaps it will help to have our noses rubbed in some accounts of truly destructive inflation. (It can happen here!)

Box 8-2 shows the course of inflation in the Roman empire over a period of some three centuries.[24] The economic measure is the number of drachmas (originally a silver coin) required to buy one artab -about a bushel -- of wheat. During the first century and a half (from 30 A.D. to 180) money depreciated by some 80 percent in real value. Then for seventy years it was constant. In the next twenty years it depreciated 92 percent; and in the

next thirty years, 85 percent more. Cumulatively, from 30 A.D. to the year 300, the drachma lost 99.76 percent of its value. In the year 301 the emperor Diocletian, in an attempt to arrest hyperinflation, instituted price controls, decreeing death or exile for violators.

Box 8-2. Four Centuries of Inflation in Ancient Rome.

The price of an artab (approximately one bushel) of wheat in drachmas dates, anno Domini.

Date	Price
30	3
130	10
180	16
250	16
270	200
300	1,300
301	[Diocletian enacts his laws]
314	10,000
334	84,000
344	2,000,000
410	[The Visigoths enter Rome]

Diocletian's laws didn't work, of course: stern measures imposed on a large population seldom do. Before another half-century had passed the drachma had declined to 0.0015 percent of the value it had at the time of the death of Christ. Understandably, later administrators collected their taxes "in kind," that is, in wheat and other material goods, rather than in money. Not the least of the evils of inflation is the way it ruins a system of easy exchange (money). To put the matter another way: with hyperinflation a money economy degenerates into a barter economy. Barter economy may be fair, but it certainly squanders human time. (If my chickens produce more eggs than I can eat, how many trades must I engineer before I can acquire the bicycle I need?)

At some point a government becomes powerless to stop inflation, but it can always make it worse. Politicians often strengthen their position by actually promoting inflation. Controlled prices create a "black market." Morally, a government should try to stamp out this kind of market, but all too often rulers seek their personal advantage rather than the welfare of the nation at large. During World War II the Chungking government of China, riding inflation like a bucking bronco, was supported by infusions of U.S. money. At one time the $5 that bought one pack of cigarettes on the legal market would buy 162 packs on the black market. The Chungking government credited their American lender with Chinese money at the official rate, but spent the money at the black market rate. The suffering experienced by those who live through a period of runaway

inflation can scarcely be imagined by the inexperienced. The "normal," slow advance of inflation is dwarfed by rare and explosive outbreaks of hyperinflation. During the nineteenth century many government and private pension plans flourished in Europe. The funds in these systems were invested conservatively; perhaps none at more than 5 percent interest. Investors were told that their money was absolutely safe. Following the widespread destruction of capital goods in World War I, great readjustments of national currencies took place throughout Europe. At the worst, a German pensioner whose nest egg had accumulated 5 percent per annum compound interest lost in one day the capital it had taken him 3,033 days to accumulate. In four such days the loss would equal the accumulation of a working lifetime of thirty-three years. Less than a week destroyed all the pensioner's dreams of a gracious old age. It is no wonder that suicide became a substantial cause of death in what had once been flourishing economies.

"Bad Luck" and the Stability of Systems

That a conspiracy of silence surrounds the institution of compound interest is quite understandable. To encourage the loyalty of their workers, those in charge of any socioeconomic system feel they must claim that the system is absolutely stable. And, as we have learned, some bankers even have the nerve to incorporate the word "perpetual" in names of their institutions. (One can easily imagine what would happen to an institution that bore the honest name of "Perpetual-Till-the-Time-of-Troubles National Bank.") The brute, undeniable fact is that compound interest by itself creates an inherently unstable system in a world of finite physical resources -- which is the only world available to us.

It is time to see how we have gotten where we are, and what we may expect in the future, as regards usury. The dominant attitude of the ancients is well expressed by Aristotle:

> There are two sorts of wealth-getting: one is a part of household management, the other is retail trade. The former is necessary and honorable, while that which consists in exchange is justly censored; for it is unnatural, and a mode by which men gain from one another. The most hated sort, and with the greatest reason, is usury, which makes a gain out of money itself and not from the natural object of it. For money was intended to be used in exchange, but not to increase at interest. This term "interest," which means the birth of money from money, is applied to the breeding of money because the offspring resembles the parent. Of all modes of getting wealth this is the most unnatural.[25]

Sixteen centuries later we find Oresme saying much the same sort of thing: "It is monstrous and unnatural that an unfruitful thing should breed, that a thing specifically sterile, such as money, should bear fruit and multiply of itself."[26]

Oresme was one of the last of the supporters of the old view that usury is intrinsically abnormal and wicked. After Oresme, limited usury (renamed "a reasonable rate of interest") was supported by Christianity, and later by an overwhelming majority of economists.

It is easy to make a case that the progress of the European world into modern prosperity would have been greatly impeded by a ban on usury. Usury is justified by its fruits: debt, growing exponentially, marvelously motivates borrowers to find new ways of exploiting nature. The historical defense of usury can be reduced to the lines inscribed on a memorial to the architect Christopher Wren: *Si monumentum requiris, circumspice* -- "If you seek [its] monument, look around you." Compare the wealth and the vast physical infrastructure of the Western world, where usury has been practiced for eight centuries, with the poverty of most of the countries where usury has not been systematically practiced. The man in the street regards usury as normal, decrying as abnormal the phenomena of inflation, bankruptcy, debt repudiation, and confiscatory taxation. But it is only through the persistence of the "bads" that the "good" called interest can continue to exist.

In this matter, as in others, the economist John Maynard Keynes stands out as an exception in his profession. In 1930 he expressed his opposition to usury not in a systematic development of an alternate proposal but in a familiar essay outlining the "Economic Possibilities for our Grandchildren." Some day we may, he said,

> return to some of the most sure and certain principles of religion and traditional virtue -that avarice is a vice, that the exaction of usury is a misdemeanor, and the love of money is detestable .... But beware! The time for all this is not yet. For at least another hundred years we must pretend to ourselves and to every one that fair is foul and foul is fair for foul is useful and fair is not. Avarice and usury and precaution must be our gods for a little longer still.[27]

More than half of "another hundred years" have passed and usury still persists. Keynes's intellectual grandchildren are moving into power. Will the grandchildren's grandchildren put an end to usury? Perhaps the best advice for those seeking prosperity for themselves and for the community at large may well be to follow the usurious path -- for a perilous little while longer.[28]

The change, when it comes, may well be sudden and painful, because it will demand an inversion of traditional values. A post-usurious society will insist that:

1 Usury is abnormal (and it may be called "wicked");

2 Inflation, bankruptcy, debt repudiation, and confiscatory taxes are the necessary corrective measures required for stability in a usurious society; and

3 For reasons of fairness, the practice of usury must be strictly regulated by the community, and banned in many instances.

For six centuries "informed opinion" has regarded the unlimited paying of interest on money as normal and generally desirable. People have assumed without question that material wealth can grow exponentially forever. Now we must admit that only debt can grow exponentially forever: that an exponential curve that soars off toward infinity can apply to nothing in the real world; and that such unpleasant events as inflation and debt repudiation are necessary correctives in a social system based on usury. The intellectual revolution demanded is a formidable challenge -- for our children if not for us.

Notes and References

1. The ready availability of "electronic slide-rules" in financial and scientific models makes it easy for the reader to check the figures that follow. If *ln* = the natural logarithm, and *i* = the annual rate of interest stated as a decimal fraction, then the compound interest formula can be given as:

$$ln(\text{value}) = ln(\text{deposit}) + [(\text{time}) \times ln(1 + i)]$$

   Once the logarithm of the value is found, one takes the antilogarithm (e^x, on the calculator) of this figure, which gives us what we want.

2. Edward R. Tufte, *The Visual Display of Quantitative Information* (Cheshire, CT : Graphics Press, 1983). This handsome volume is by far the best manual on the art of converting figures into graphs.

3. The distinction between numeracy and literacy is made at the end of the second chapter of this book. For more details see: Garrett Hardin, *Filters Against Folly: How to Survive Despite Economists, Ecologists, and the Merely Eloquent* (New York: Viking, 1985; Penguin edition, 1986).

4. The division of academia into two cultures was made in 1959 by C. P. Snow (1905- 1980), a British physicist turned administrator. (See his *Two Cultures and the Scientific Revolution* [Cambridge: Cambridge University Press, 1959].) His analysis was vigorously attacked by the literary critic F. R. Leavis. As a broad-brush description, most scientists think Snow's distinction is close to the truth. In any case, Snow could claim some knowledge of both cultures, since he was also a successful novelist. In the present work, the discrimination of three investigative filters is derived from Snow's two cultures.

5. This is a plea, of course, for more graphing in public education; but I am not unaware of the fact that reforms can easily miscarry. Consider, for instance, the words of Alfred North Whitehead, referring to the English situation at the time of World War I: "A few years ago there was an outcry that school algebra was in need of reform, but there was a general agreement that graphs would put everything right. So all sorts of things were extruded, and graphs were introduced. So far as I can see, with no sort of idea behind them, but just graphs. Now every examination paper has one or two questions on graphs. Personally, I am an enthusiastic adherent of graphs. But I wonder whether as yet we have gained very much." *The Organisation of Thought* (London: Williams and Norgate, 1917), 15. The moral may be simply stated: Pedagogues can spoil any good idea.

6. John Maynard Keynes, *The Economic Consequences of the Peace* (London: Macmillan, 1919), 153.

7. Ibid., 3.

8. Garrett Hardin, *Nature and Man's Fate*. (New York: Rinehart, 1959), 307.

9. Joseph Fletcher, *Situation Ethics: The New Morality* (Philadelphia: Westminster Press, 1966).

10. Benjamin Nelson, *The Idea of Usury: From Tribal Brotherhood to Universal Otherhood*, 2d ed. (Chicago: University of Chicago Press, 1969).

11. P. T. Bauer, "Remembrance of Studies Past: Retracing First Steps, in *Pioneers in Development*, ed. Gerald M. Meier and Dudley Seers, (New York: Oxford University Press, 1984), 28, 29).

12. *The Correspondence of Charles Darwin*, vol. 1. (Cambridge: Cambridge University Press, 1985), 233.

13. Garrett Hardin, "Running on 'Empty'" *BioScience* 36 (1986): 2.

14. See, for instance, *The Ecologist*(U.K.), 15, 16, and 17 (1985-1987).

15. Robert Repetto, "Wasting Assets," *Technology Review*, January 1991, 39-44.

16. To see what a barrow is, look at a reproduction of Breughel's painting of "The Wedding Feast," the original of which is in Vienna's Kunsthistorisches Museum. In this scene, food is being brought into the room by two men, one at either end of the barrow. The date of the painting is 1568, long after the invention of the wheelbarrow, but barrows without wheels were then, and are now still, improvised on occasion.

17. Martin Mayer, *The Greatest-Ever Bank Robbery: The Collapse of the Saving and Loan Industry* (New York: Scribner's, 1990), 299-300.

18. Herman E. Daly, "The Economic Thought of Frederick Soddy," *History of Political Economy* 12 (1980): 469-88.

19. *Wall Street Journal*, 5 March 1975, 1.

20. Frederick Soddy, *Wealth, Virtual Wealth, and Debt* (London: Allen & Unwin, 69).

21. James R. Newman, ed., *The World of Mathematics* vol. 1 (New York: Simon & Schuster, 1956), 514. The passage quoted there is from E. T. Bell, *Mathematics--Queen and Servant of Science*.

22. Laurence J. Kotlikoff "The Deficit is Not a Well-Defined Measure of Fiscal Policy." *Science* 241 (1988): 791-95.

23. Will and Ariel Durant, *The Age of Reason Begins* (New York: Simon & Schuster, 1961), 275.

24. Lionel Casson, "Biting the Bullet in Ancient Rome," *Horizon* 18 (1976): 18-21.

25. Aristotle, *Politics*, book 1, chap. 10.

26. James Simon, *A Dictionary of Economic Quotations*, 2d ed. (London: Croom Helm, 1984). The original is in Oresme's *The Origin, Nature, Law and Alterations of Money*.

27. John Maynard Keynes, *Essays in Persuasion* (New York: Norton, 1963), 371-72.

28. It is noteworthy that the 1988 Nobel prize in economics was awarded to Maurice Allais of France, who, in 1947, set forth a theory that postulated that the optimum rate of interest in a truly stationary economy is zero. See *Science* 242 (1988):51 1.

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