POSTSCRIPT

It’s hard to make predictions—especially about the future.
Niels Bohr

WHERE ARE WE GOING?
AND HOW DID WE GET INTO THIS HANDBASKET?

When I was a young man, there was always an unspoken assumption in America that the future was necessarily going to be better than the present. (But not any more!) In those heady times the ‘Journal of Record’ of the American Physical Society: The Physical Review, started appearing twice monthly; and over time, it multiplied and grew steadily thicker. Surely we felt that it was a harbinger of good things to come. But by the 1960s someone had already calculated that the number of physics journal articles was actually growing exponentially, (like the rabbit plague in Australia). This revelation brought about a slight chill, for we couldn’t avoid thinking of all those brooms in the story of The Sorcerer’s Apprentice, (with music by Paul Dukas, played by the Philadelphia Orchestra, conducted by Leopold Stokowski, with Mickey Mouse in the starring role). Some of us must have realized that the party was going to have to end some day. But most of us, myself included, stupidly saw the course of Science and Civilization as a monotonically ascending curve. Peak civilization? Fiddlesticks! The sky’s the limit, and the world’s our oyster! And what fools we were!

At that time the wealth of the United States was at its apogee, a fact that obscured one of the most fundamental laws of Science: Somebody always has to pay the bills! And science always costs money. These bills were growing exponentially, just like the number of pages of articles in the journals. What we didn’t realize until more recent times, was that a good deal of the growth of scientific discovery and of its laboratories in this country, was simply window dressing for the Cold War with the Soviet Union. Believe me, our ruling classes have never been consumed with a burning curiosity about the significance of Bell’s Theorem! What we in science had really been doing was to give them a sufficiency of weaponry to attempt to achieve a lasting hegemony over the whole world. What they really lusted after was: Empire. And they are fools, too!

In the year 1897 Queen Victoria celebrated her Diamond Jubilee, and for this occasion Rudyard Kipling wrote the well-known poem: Recessional. In the poem one finds a passage that mentions the fate of two ancient empires: those of Nineveh and Tyre. Kipling hoped fervently that this wouldn’t happen to England. These post 9/11 days certainly seem to be full of ‘Kipling moments,’ don’t they? This is a consideration that brings us inevitably to the subject of ‘political-economic astrophysics:’ Birth and Death.

At the beginning of its existence a star is almost exclusively composed of hydrogen nuclei, which are pulled by gravity toward the star’s center. As they fall inward, these nuclei collide with others of their kind; and if the collision is violent enough, the two hydrogen nuclei will coalesce to form a nucleus of ‘heavy hydrogen,’ (called: deuterium). This is the kind of process that produced the build-up of all the heavier elements, a process called nucleogenesis. Two deuterium nuclei will eventually combine to form a helium nucleus. As far as I know, just about every atom in the universe has started its career in this manner. But helium, the product of this process, 0.7% lighter than the four initial hydrogen atoms; and it is this difference in mass that produces enough energy to counteract the inward pull of gravity, stemming the flow of atoms toward the center of the star. (Note: Curiously, if the ‘0.7%’ were even slightly different from its observed value, we wouldn’t even exist. Remarkable!) But the life of the star
is one of continual struggle against the gravitational forces conspiring to produce its collapse. For most of its career, a star lives by burning hydrogen—using up its savings account and credit cards.

How long can this process go on? I give you this answer: The lifetime of the star depends crucially on its mass. A massive star will exert a stronger gravitational pull upon the hydrogen nuclei that constitute its fuel, thereby producing more collisions per unit time, and therefore liberating correspondingly more energy. Since its initial supply of hydrogen, though large, is still finite, the life of a giant star will be correspondingly brief—much briefer than that of a star of more modest proportions. This is a point that will prove to be a vital one when we compare the life of a star to that of a civilization.

As more and more helium is produced, correspondingly less hydrogen will remain; and so, inevitably, helium nuclei will start to collide with each other. However, the result of this union is a very strange one. The result of a collision between two helium nuclei is a very unstable isotope of beryllium, one with a very short lifetime. But if, while the two helium nuclei are still sticking together, a third helium nucleus happens to come along, the whole mess coalesces—into a nucleus of carbon! If this improbable quirk of nature had not been available, there would be no life in the universe! As the physicist Freeman Dyson, once expressed it: “The universe must have known that we were coming.”

As the burning of helium comes to constitute the dominant mode of metabolism for a star, a strange transformation occurs within its body. It ejects a part of its mass, which forms a vast, cool envelope, and in time it becomes what is called a Red Giant. The atoms in the envelope, (the 99%) no longer contribute to the star’s energy economy, and the real business of burning is now taking place in a small, white-hot region at the heart of the Red Giant, a region that is, in effect, a White Dwarf, (home of the 1%). There is an obvious analogy here to our own situation, right? The nuclei in the White Dwarf constitute a kind of celestial oligarchy.

With the passage of time this scenario continues to play itself out. The hungry star proceeds to “burn its way up the Periodic Table—until it reaches the element: iron. The star has by then reached its ‘tipping point.’ Past that point, every successive event of nucleogenesis requires more energy than it can deliver in return, making it impossible to stave off that implacable bill-collector: Gravity. The star has run out of fuel. Past this point various collapse scenarios present themselves. Small stars, (like our sun), merely become White Dwarves, and seem to subside ultimately into a kind of stellar ash. Larger stars, perhaps five times the size of the sun, will become supernovas, and collapse into neutron stars, a mere seven or eight miles in diameter; while the real giants will implode upon themselves, dragging with them the very fabric of space-time, as they sink out of the universe, becoming black holes.

As an aside, I can’t resist the temptation to mention that such a cataclysm, the one attending the death of a star—a supernova, will scatter a host of heavier nuclei across the star fields of space. These nuclei are gathered up in the gravitational field of other, younger stars, perhaps becoming incorporated into planets. And it is just these nuclei that will come to provide the atoms essential for life in the universe. It is from such monstrous events that arise the beauty and variety of life. We all know that the central atom of hemoglobin is iron, so a star must die bring blood into our bodies.

And now back to my story. In the Introduction to this book I likened civilizations to stars. After all, they are both kinds of heat engine, so they both require a steady diet of fuel in order to live. In the case of our own civilization, we have been feeding off of sunlight ever since one of our ancestors discovered fire.
Think about it! Plants require photosynthesis in order to live; they constitute distilled sunlight. Animals, including humans, subsist off of plants, or other animals. Thus we, too, live on a diet of sunlight. Coal, oil and natural gas are really ‘ancient sunlight,’ as author Thom Hartmann once pointed out; and the right to burn coal was given by royal permission to the freemen of Newcastle in about the year 1397CE. Out of this continuing raid on the Bank of Ancient Sunlight, as well as the from the pillage of the New World, that was born the wealth, (even the social optimism), of the past quarter-millennium. And of course there came the rise of the great empires, as well as the rise of Modern Civilization. It is interesting to note that in previous civilizations, whenever available energy became scarce, wealth and its concomitant political power became limited to a tiny fraction of the population, who proceeded to act as if it were theirs by Divine Right. It is even more disturbing to find that most of the time the great majority, the commoners, usually submitted meekly to this demeaning arrangement.

Joseph Tainter, Professor of Sustainability at Utah State University, has for decades been a student of civilizational collapse. In his book: Drilling Down, co-authored with Tadeusz Patzek, he offers valuable knowledge about the slow disintegration of the Roman Empire. It had reached its apogee by the year 235CE, and had achieved this condition by means of the subjugation of the other countries in Europe, North Africa and Asia Minor. It had acquired wealth and dominance by expropriating the wealth of other countries. Tainter expressed this astutely as “stolen sunlight.” By the middle of the third century, the empire had become overextended, and had very slowly begun to implode. From that point it ‘bought time’ by means of its common citizens into penury, thousands of them became hopelessly indebted. These unfortunate people were sold into slavery. (This is not a very strange notion; when we consider it in the context of the present-day student loans). In the United States today it is estimated that the 400 or so billionaires control an amount of wealth equal to the wealth possessed by that fraction of the population dwelling below the 50th percentile. This is not good news, is it? This would be especially true if you had, from childhood, been inculcated with our societal myth: that Western Civilization was the way of the future, and that the future will always be better. Let’s see what Aldous Huxley had to say about our country.

Huxley was a prophet for our times. He died on November 22nd 1963, and his book: Brave New World Revisited appeared in 1958. In its pages he had some wise advice to give:

But the increasing pressure of numbers upon available resources is not the only force propelling us in the direction of totalitarianism. This blind biological enemy of freedom is allied with immensely powerful forces generated by the very advances in technology of which we are most proud. …

But the Nature of Things is that nobody in this world ever gets anything for nothing. These amazing and admirable advances have had to be paid for—and each installment is higher than the last. Many historians, many sociologists and psychologists… point out, for example, that democracy can hardly be expected to flourish in societies where political and economic power is being progressively concentrated and centralized. But the progress of technology has led, and is still leading, to just such a concentration and centralization of power. …

…a capitalist democracy, such as the United States,… is controlled by what Professor C. Wright Mills called the Power Elite. This Power Elite directly employs several millions of the country’s working force in its factories, offices and stores, controls many millions more by lending them the money to buy its products, and through its ownership of the media of mass communication, influences the thoughts,
the feelings and the actions of virtually everybody. To parody the words of Winston Churchill, never have so many been manipulated so much by so few. …

The best of constitutions and preventive laws will be powerless against the steadily increasing pressures of overpopulation and of the over-organization imposed by growing numbers and advancing technology. The constitutions will not be abrogated and the good laws will remain on the statute book; but these liberal forms will merely serve to mask and adorn a profoundly illiberal substance. Given unchecked overpopulation and over-organization, we may expect to see in the democratic countries a reversal of the process which transformed England into a democracy, while retaining all the outward forms of a monarchy. Under the relentless thrust of accelerating over-population and increasing over-organization, and by means of ever more effective methods of mind-manipulation, the democracies will change their nature; the quaint old forms—elections, parliaments, Supreme Courts and all the rest—will remain. The underlying substance will be a new kind of non-violent totalitarianism. All the traditional names, all the hallowed slogans will remain exactly what they were in the good old days.

Democracy and Freedom will be the theme of every broadcast and editorial—but democracy and freedom in a strictly Pickwickian sense. Meanwhile the ruling oligarchy and its highly trained elite of soldiers, policemen, thought-manufacturers and mind-manipulators will quietly run the show as they see fit. Thus it is a political axiom that power follows property. But it is now a historical fact that the means of production are fast becoming the monopolistic property of Big Business and Big Government. Therefore, if you believe in democracy, make arrangements to distribute property as widely as possible.

At this point you may be asking yourself: “Who was Aldous Huxley?” He was the grandson of Thomas Henry Huxley, Charles Darwin’s champion in the fight to gain acceptance for the Theory of Evolution. His brother Julian, as well as his half-brother Andrew, both won Nobel Prizes in biology. Aldous, as I recall, originally intended to follow in his father’s footsteps and become a physician, but the aftermath of an eye injury left him almost blind. His prophetic novel: *Brave New World*, which appeared in 1931, brought him lasting fame. The perceptiveness that he displayed in the above grim analysis of the fate of democratic government never ceases to leave me in a state of awe. Huxley wasn’t always right; but he was always brilliant. Further, he was a decent man, and revered for his kindness and compassion.

To return to my original narrative, the hydrogen-burning phase of America began to sputter out in the early 1970’s, and the White Dwarf phase (a kind of self-cannibalization), commenced in the 1980s. This seems to correspond to the state of the Roman Empire in the mid-third century, CE. In the United States more than 2,500,000 people are in the clutches of the so-called: ‘criminal justice’ system: (It depends on how you parse that phrase). Loans to college students have already surpassed a trillion dollars, and much of this gargantuan sum will be unredeemable. Thus, *The System is broken*! And there is very little prospect for a cure for this disease, because too many powerful people are making money from it.
And Now For That Perfect Storm, Brought to Us by Western Civilization…

There is no secret here. Western Civilization has been kept in existence by the burning of fossil fuels—Ancient Sunlight. The waste products of this enterprise are threatening to kill the planet whereon we live. Most of us are aware that temperature records are continually being broken. If we ceased burning carbon compounds tomorrow, temperatures are expected to go on climbing for decades—perhaps even centuries. But much, if not most, of the carbon dioxide that we are releasing is being absorbed by the oceans, thereby increasing their acidity, making them inhospitable to life. According to present estimates, the oceans are more acidic today than at any time in the past 300,000,000 years. The end product of this process is terrifying to contemplate. So I hope you won’t mind if I call this: The Worst Case Scenario, (in that it is to be avoided at absolutely any cost). Professor Michael T. Klare (fears that this is just what is going to happen. He is quite an expert; and you can find him on Google. If you read what he has written though, you’ll find that he doesn’t say much about the practicalities of drilling for ‘tight oil,’ by which I mean ‘fracking’ and scrounging for bitumen, (as they are doing in Alberta). So we need to look elsewhere. Fracking destroys vast amounts of potable water, and water is a scarce commodity on this planet. And there can be no life without it.

The Second Scenario is an extension of our previous excursion into the realm of astrophysics. Instead of hydrogen, (hard to find in burnable form), the fuel in question is Ancient Sunlight. In particular, I mean oil, because it is so easily transported, and it is the source of gasoline. What I want to talk about is the concept of peak conventional oil. This definition temporarily allows me to exclude talking about ‘tight oil.’

What can we conclude about the production of this stuff? My information comes from an article in Wikipedia. According to the IEA, (Int’l Energy Administration): Of 811 oil fields, their output is declining at an average of 6.7% per year. This implies that, in about 12 years, (the year 2024) the output will have fallen by one-half. Of the largest 48 fields, 33 of them are known to be in decline. Of course, (the good news), there is more drilling, and there are more minor discoveries going on continually, so that, for now, worldwide oil production is declining at only 4.1% per year. At that rate there will be half as oil as there is at present in the year 2031. So, for conventional oil, the peak occurred (probably) in 2005, (on Thanksgiving Day). It could have happened as late as 2007. But in any case, conventional oil is becoming, as they say: ‘history.’ To keep the lights burning in the homes of Western Civilization, it has been estimated that it will require the discovery of a new Saudi Arabia every 3-4 years. “good luck with that one.” Try prospecting on the moon!

So, then how about ‘tight oil’? After all, have we not heard from our politicians that the United States has enough ‘tight oil’ to qualify as the new Saudi Arabia? Not so fast! At present there are two major sources of ‘frackable’ oil in the ‘lower 48’: one in North Dakota, and the other in Southeast Texas. It was initially hoped that the United States would be able to wean itself off of its dependence of foreign oil by means of fracking, but the rosiest estimates for ‘tight oil’ predict a maximum output of 5 million bpd, (barrels per day). The U.S. presently imports an amount of oil equal to 9 million bpd. This, combined with its domestic production, adds up to 18 million bpd, for the total daily oil consumption. A retired oil executive recently delivered a lecture at University College London, and used the following amusing simile:

"We’re like a cage of lab rats that have eaten all the cornflakes and discovered that you can eat the cardboard packets too. Yes, we can, but... Tight oil may reach 5 or even 6"
million b/d in the US, which will hugely help the US economy. Tight oil production in the US is likely to peak before 2020. There absolutely will not be enough tight oil production to replace the US' current 9 million b/d of imports."

There is an all-important ratio that is useful for us to understand the effect of peak oil on our future, and that of our descendants: It is: *Energy Recovered Over Energy Invested*, EROEI. If you require the energy in one barrel of oil in order to receive ten barrels, then The Ratio is equal to: 10. (Back in the 1940’s EROEI was usually equal to about 100, but those days are gone forever). In the case of fracking, The Ratio is less than five. What does this mean for the price at the gas pump? The Answer: very expensive oil (like a bottle of Cabernet Sauvignon). On the day when I wrote these words the price of a barrel of crude oil was about $102.50; it has been oscillating narrowly around $100 for quite a while now—but not forever. At the point when the price rises dramatically, the world economy will go ‘into the ditch’, and stay there. Thus ends the petroleum engineering part of my story.

In addition to the book by Tainter and Patzek, you should read *The End of Growth* by Richard Heinberg. You can find him on Google, also. It is Heinberg who looks clearly at our Perfect Storm from the standpoint of peak oil, and concludes that *Growth must have a stop!* Believe me, this will happen, no matter what we do!

**When The Lights Go Out**

It is very interesting to try to visualize what will become of us, once the price of a barrel of oil reaches the $200/barrel range. The author I wish to recommend is: James Howard Kunstler. His best book is: *Too Much Magic*. The society in which we live is a result of the existence of cheap oil. Let me name a few items looming large on our cultural landscape: the giant interstate highway system, and its creation: suburbia, with its yellow school buses and big schools with their 3000-student enrolments; megacities, with their skyscrapers; (did you ever wonder how much energy it takes to operate the toilets and water faucets on the 34th floor?). Ask yourself what this will do to those gargantuan boondoggles like the California Water Project. And this is only the beginning. Imagine, for a moment, the fate of Phoenix or Las Vegas, when there is no more power to operate the air conditioners—and then apply this idea to the rest of the country, and you will begin to understand the future. And all those shopping malls? The parking lots may not all be empty, but people will be living in the cars.

And there is more: Our mental world has been thoroughly sculpted by oil. There are propositions that have “stood to reason” for so long that we hold them to be “self evident.” Cheap oil has not been uniformly beneficial. It has created the solipsistic human, one who commutes and shops with the aid of an oil-driven box with wheels. We all move around in, and inhabit, boxes; for that’s the way we live.

The electronics that makes my little laptop computer possible, also makes it possible for a corporate-linked government to eavesdrop on every key-stroke, every phone call. Why is this? They do it because they *can*! Remember what Aldous Huxley said about the hidden cost of the technology that makes us all prisoners! And that huge building, the one that the NSA has created in Utah in order to store ‘yottabytes’ of information? I have heard that this contraption uses twice as much energy as does Salt Lake City, and few of us will miss it when its lights go out.

So, what will day-to-day life be like? The show will go on, but doubtless it will have a much smaller cast. Beyond this, I don’t know. I *do* know that societal cohesiveness, a bulwark against anarchy, will be
essential to survival—and this implies something personally distasteful to me: conformity, social control. We may well get a replay of the Middle Ages, (but with worse music). However, this scenario may have one saving feature: life on earth may survive. And that, to me, is everything! Mother Nature probably regrets having turned the earth over to the apes, i.e., Us.

Lord Kelvin, as you will remember, could also visualize two clouds on his scientific horizon. I believe I can discern a third cloud. If you know anything about Wall St. and the actions of the Federal Reserve, you will understand what I am saying. As of today, the stock indexes are overvalued by about two to one. In short, there is a monster bubble. Part of this is due to the fact that corporations are repurchasing their own stock. For another thing, speculators have been buying stock “on the margin.” This means that they buy stock with money that they borrow from their investment bank. As long as the indexes continue to rise, this tactic works. But once the indexes turn downward, the bank must get ‘a transfusion’ of money from the speculator—the guy who has spent his last dime on stock certificates. So the bank puts out a ‘margin call.’ The speculator is required to return some, or all of the borrowed money. But it no longer exists. Every time this has occurred in the past the result has been a ‘crash.’ What I have outlined is merely part of the problem. Our economic house is built on toothpick foundations, and the result will be an avalanche. You ask: When will the crash occur? I don’t know! But I do know one thing. It will occur! Betting on human short-sightedness, stupidity and greed is betting on a ‘sure thing.’ Compared to the effect of Global Warming, this is the good news.

The end of the medieval world was accompanied by a slow societal collapse, wherein the old institutions, the old attitudes, the old forms disappeared. It took nearly six centuries in Europe (1337-1918) to complete the transition. By the time this show is over, all of our present expectations, those propositions that “stand to reason,” will have been discarded and forgotten. The old ‘forms’ will have been discarded. And we will not have such a long grace period to adjust to our new situation.

Let me end this book on a more cheerful note. If we do not succeed in “cooking the world for dinner,” we will be forced to live severely within our means. But Modern Life is absurd, in that there is an absence of meaning. After the collapse, there will be no more television, no automobiles, no National Security Agency. Transportation will be severely circumscribed. When computers break, no one will remember how to fix them. Horses will be seen more often on the decayed roads. Ultimately new engines of social control will doubtless be constructed, and we will be forced again to contend with despotism. But after the fall of the Roman Empire, at least 600 years elapsed before the kings and popes managed to reestablish social control. Sometimes it is useful to take the long view. Modern Civilization has been a quasi-solution, and we are awash in Residual Problems. So weep not!