MADMEN AND ECONOMISTS

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Introduction[1]

"Anyone who believes in indefinite growth in anything physical, on a physically finite planet, is either mad or an economist." - Kenneth E. Boulding (1910-1993)

Why Are Economists Addicted to Growth?

Economists (with a few notable exceptions) have long behaved as though growth were synonymous with economic health.

If the gross national product of a country increases steadily by 4 percent per year, most economists express approval and say that the economy is healthy.

If the economy could be made to grow still faster (they maintain), it would be still healthier.

If the growth rate should fall, economic illness would be diagnosed. However, it is obvious that on a finite Earth, neither population growth nor economic growth can continue indefinitely.

But why do economists cling almost religiously to the idea of growth?

In general, growth brings profits to speculators. For example, purchase of land on the outskirts of a growing city will be rewarded as the land increases in value.; and when the economy grows, stocks rise in value.

Today, as economic growth falters, the defects and injustices of our banking system have come sharply into focus, and light has also been thrown onto the much-too-cozy relationship between banking and government.

The collapse of banks during the subprime mortgage crisis of 2008 and their subsequent bailout by means of the taxpayer's money can give us an insight into both phenomena the faults of our banking system and its infiltration into the halls of government.

The same can be said of the present national debt crisis in the Euro zone and elsewhere.

One feature of banking that cries out for reform is "fractional reserve banking", i.e. the practice whereby private banks keep only a tiny fraction of the money entrusted to them by their depositors, and lend out all the remaining amount.

[1] This book draws heavily on chapters that I have previously published in various books, but a considerable amount of new material has also been added.

By doing so, the banks are in effect coining their own money and putting it into circulation, a prerogative that ought to be reserved for governments. Under the system of fractional reserve banking, profits from any expansion of the money supply go to private banks rather than being used by the government to provide social services.

This is basically fraudulent and unjust; the banks are in effect issuing their own counterfeit money.

When the economy contracts instead of expanding, the effect of fractional reserve banking is still worse. In that case the depositors ask the banks for their money, which it is their right to do.

But the banks do not have the money - they have lent it out, and thus they fail. However, the bankers have insured themselves against this eventuality by buying the votes of government officials.

Thus the banks are bailed out and the taxpayers are left with the bill, as in the recent example in which the US Federal Reserve secretly gave 7.7 trillion of the taxpayers' dollars to bail out various banks.

Information-Driven Population Growth

Today we are able to estimate the population of the world at various periods in history, and we can also make estimates of global population in prehistoric times.

Looking at the data, we can see that the global population of humans has not followed an exponential curve as a function of time, but has instead followed a hyperbolic trajectory.

At the time of Christ, the population of the world is believed to have been approximately 220 million. By 1500, the earth contained 450 million people, and by 1750, the global population exceeded 700 million.

As the industrial and scientific revolution has accelerated, global population has responded by increasing at a break-neck speed: In 1930, the population of the world reached two billion; in 1958 three billion; in 1974 four billion; in 1988 five billion, and in 1999, six billion.

Today, we have reached 7.7 billion, and roughly a billion people are being added to the worlds population every fifteen years.

As the physicist Murry Gell-Mann has pointed out, a simple mathematical curve which closely approximates the global population of humans over a period of several thousand years is a hyperbola of the form P =

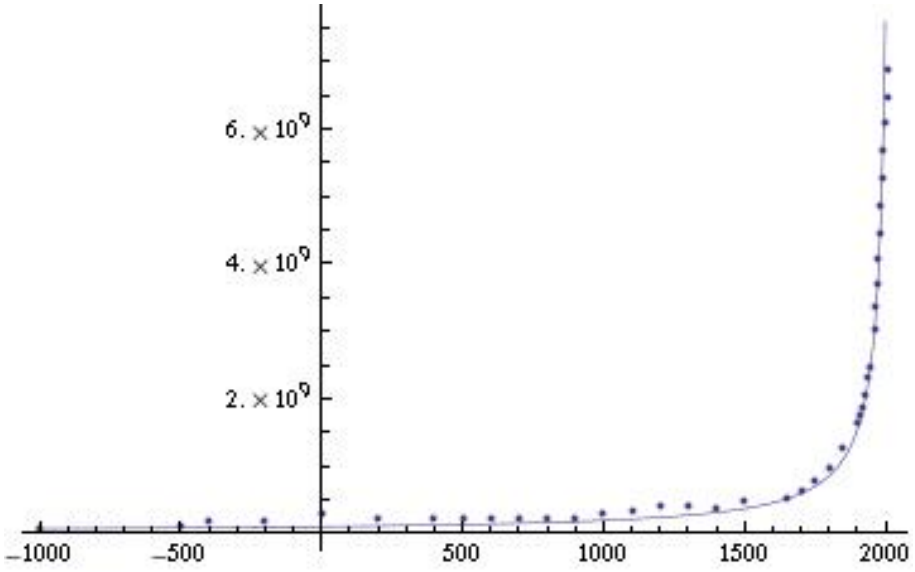

Figure 1: **The simple mathematical curve that fits best to human population data over the last 3,000 years is not an exponential increase, but rather a hyperbola of the form P=C/(2025-t). Here P represents population, C=190,000,000,000 and t is the year. The curve goes to infinity at t=2025 (only a few years away), which is of course impossible. Global population has already started to fall away from the hyperbolic trajectory. Will it level off, or will it crash disastrously? Because of the enormous amount of human suffering that would be involved in a population crash, the question has great importance.**

190,000,000,000/(2025-t). Here P represents the global population of humans and t is the year.

How are we to explain the fact that the population curve is not an exponential? We can turn to Malthus (Appendix A) for an answer: According to his model, population does not increase exponentially, except under special circumstances, when the food supply is so ample that the increase of population is entirely unchecked.

Malthus gives us a model of culturally-driven population growth.

He tells us that population increase tends to press against the limits of the food supply, and since these limits are culturally determined, population density is also culturally-determined.

Hunter-gatherer societies need large tracts of land for their support; and in such societies, the population density is necessarily low.

Pastoral methods of food production can support populations of a higher density. Finally, extremely high densities of population can be supported by modern agriculture.

Thus, Gell-Manns hyperbolic curve, should be seen as describing the rapidly-accelerating growth of human culture, this being understood to include methods of food production.

If we look at the curve, P=C/(2025-t), it is obvious that human culture has reached a period of crisis.

The curve predicts that the worlds population will rise to infinity in the year 2025, which of course is impossible.

Somehow the actual trajectory of global population as a function of time must deviate from the hyperbolic curve, and in fact, the trajectory has already begun to fall away from the hyperbola.

Because of the great amount of human suffering which may be involved, and the potentially catastrophic damage to the earths environment, the question of how the actual trajectory of human population will come to deviate from the hyperbola is a matter of enormous importance.

Will population overshoot the sustainable limit, and crash? Or will it gradually approach a maximum? In the case of the second alternative, will the checks which slow population growth be later marriage and family planning? Or will the grim Malthusian forces, famine, disease and war, act to hold the number of humans within the carrying capacity of their environment?

We can anticipate that as the earths human population approaches 10 billion, severe famines will occur in many developing countries. The beginnings of this tragedy can already be seen. It is estimated that roughly 30,000

children now die every day from starvation, or from a combination of disease and malnutrition. 11 million children die in this way every year.

Beyond the Fossil Fuel Era

An analysis of the global ratio of population to cropland shows that we have probably already exceeded the sustainable limit of population through our dependence on petroleum: Between 1950 and 1982, the use of cheap synthetic fertilizers increased by a factor of 8.

Much of our present agricultural output depends on their use, but their production is expensive in terms of energy. Furthermore, petroleum-derived synthetic fibers have reduced the amount of cropland needed for growing natural fibers, and petroleum-driven tractors have replaced draft animals which required cropland for pasturage.

Also, petroleum fuels have replaced fuelwood and other fuels derived for biomass. The reverse transition, from fossil fuels back to renewable energy sources, will require a considerable diversion of land from food production to energy production.

Thus there is a danger that just as global population reaches the unprecedented level of 10 billion or more, the agricultural base for supporting it may suddenly collapse. Ecological catastrophe, possibly compounded by war and other disorders, could produce famine and death on a scale unprecedented in history - a disaster of unimaginable proportions, involving billions rather than millions of people.

Unless efforts are made to stabilize and ultimately reduce global population, there is a serious threat that climate change, population growth, and the end of the fossil fuel era could combine to produce a large-scale famine by the middle of the 21st century.

As glaciers melt in the Himalayas and the Andes, depriving India, China and South America of summer water supplies; as sea levels rise, drowning fertile rice-growing regions of Southeast Asia; as droughts reduce the food production of North America and Southern Europe; as groundwater levels fall in China, India, the Middle East and the United States; and as high-yield modern agriculture becomes less possible because fossil fuel inputs are lacking, a global famine involving billions of people rather than millions, may occur.

What Would Malthus Say Today?

What would Malthus tell us if he were alive today? Certainly he would say that we have reached a period of human history where it is vital to stabilize the worlds population if catastrophic environmental degradation and famine are to be avoided.

He would applaud efforts to reduce suffering by eliminating poverty, widespread disease, and war; but he would point out that, since it is necessary to stop the rapid increase of human numbers, it follows that whenever the positive checks to population growth are removed, it is absolutely necessary to replace them by preventive checks.

Malthus' point of view became broader in the successive editions of his Essay; and if he were alive today, he would probably agree that family planning is the most humane of the preventive checks.

Eliminating Poverty and War

In most of the societies which Malthus described, a clear causal link can be seen, not only between population pressure and poverty, but also between population pressure and war.

As one reads his Essay, it becomes clear why both these terrible sources of human anguish saturate so much of history, and why efforts to eradicate them have so often met with failure: The only possible way to eliminate poverty and war is to reduce the pressure of population by preventive checks, since the increased food supply produced by occasional cultural advances can give only very temporary relief.

Today, the links between population pressure, poverty, and war are even more pronounced than they were in the past, because the growth of human population has brought us to the absolute limits imposed by ecological constraints.

Furthermore, the development of nuclear weapons has made war prohibitively dangerous.

How Many People Can the Earth Support in Comfort?

The resources of the earth and the techniques of modern science can support a global population of moderate size in comfort and security; but the optimum size is undoubtedly much smaller than the world's present population. Some

experts estimate that a sustainable global population would have to be as low as 2 billion.

Given a sufficiently small global population, renewable sources of energy can be found to replace disappearing fossil fuels.

Technology may also be able to find renewable substitutes for many disappearing mineral resources for a global population of a moderate size.

What technology cannot do, however, is to give a global population of 10 billion people the standard of living which the industrialized countries enjoy today.

Contents

Chapter 1

ADDICTION TO GROWTH

1.1 Madmen and economists

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1.2 Fractional reserve banking

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Inside Job

The Academy-Award-Winning documentary film **Inside Job**[1] tells the shocking story of the corruption of the financial sector that led to the 2008 subprime mortgage crisis and bank

[1] https://www.theguardian.com/film/2011/feb/17/inside-job-review
https://topdocumentaryfilms.com/inside-job/

bailout. The film can be seen online free of charge, and is well worth viewing. Of particular interest are discussions of the history of bank deregulation, governmental collusion, and the destabilizing effects of the enormous derivative market.

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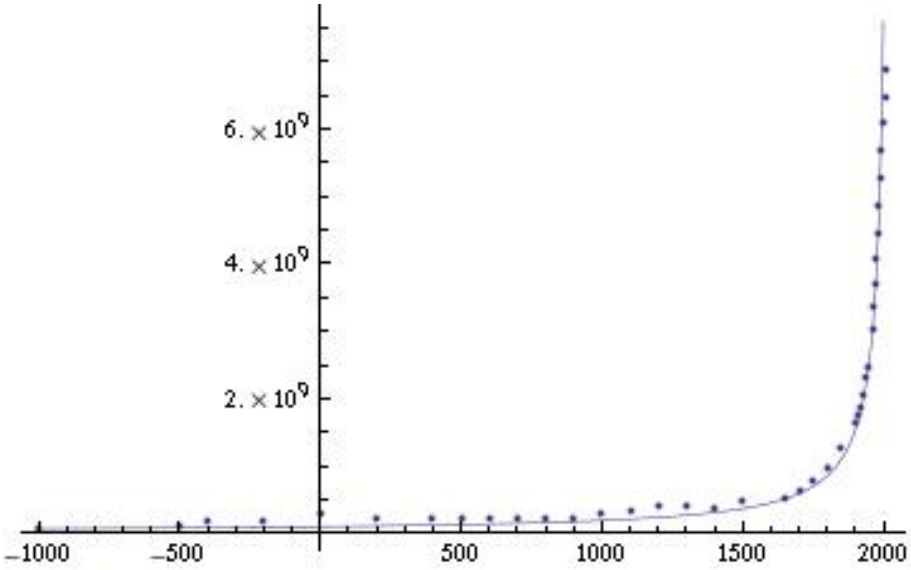

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Also, petroleum fuels have replaced fuelwood and other fuels derived for biomass. The reverse transition, from fossil fuels back to renewable energy sources, will require a considerable diversion of land from food production to energy production. For example, 1.1 hectares are needed to grow the sugarcane required for each alcohol-driven Brazilian automobile. This figure may be compared with the steadily falling average area of cropland available to each person in the world: .24 hectares in 1950, .16 hectares in 1982.

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1.4 Entropy and economics

We urgently need to shift quickly from fossil fuels to renewable energy if we are to avoid a tipping point after which human efforts to avoid catastrophic climate change will be futile because feedback loops will have taken over. The dangerous methane hydrate feedback loop is discussed in an excellent short video made by Thom Hartmann and the Leonardo DiCaprio Foundation.[2]

Celebrated author and activist Naomi Klein has emphasized the link between need for economic reform and our urgent duty to address climate change.[3]

Rebel economist Prof. Tim Jackson discusses the ways in which our present economic system has failed us, and the specific reforms that are needed. In one of his publications, he says: "The myth of growth has failed us. It has failed the two billion people who still live on 2 dollars a day. It has failed the fragile ecological systems on which we depend for

[2] https://www.youtube.com/watch?v=sRGVTK-AAvw
http://lasthours.org/

[3] http://thischangeseverything.org/naomi-klein/
http://www.theguardian.com/profile/naomiklein

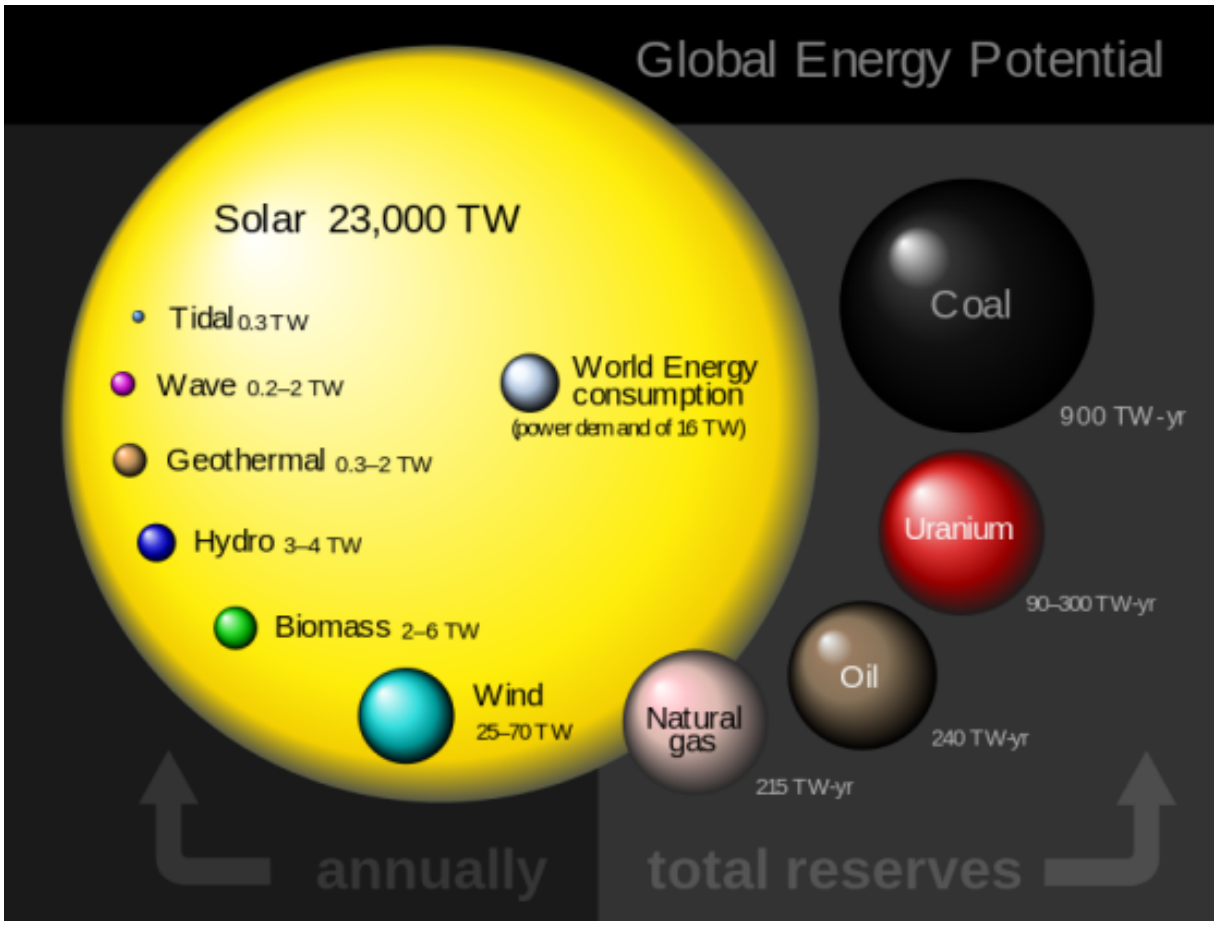

Figure 1.2: **Global energy potential. Comparison of renewable and conventional planetary energy reserves and sources. While renewables display their power potential in terawatts (TW) with the corresponding annual amount of energy, conventional sources display their total recoverable energy reserves in terawatt-years (TW-yr). Author: Rfassbind, Wikimedia Commons**

survival. It has failed, spectacularly, in its own terms, to provide economic stability and secure people's livelihood." [4]

What is entropy?

Entropy is a quantity, originally defined in statistical mechanics and thermodynamics. It is a measure of the statistical probability of any state of a system: The greater the entropy, the greater the probability. The second law of thermodynamics asserts that entropy of the universe always increases with time. In other words, the universe as a whole is constantly moving towards states of greater and greater probability.

For any closed system, the same is true. Such systems move in time towards states of greater and greater probability. However, the earth, with its biosphere, is not a closed system. The earth constantly receives an enormous stream of light from the sun. The radiation which we receive from the sun brings us energy that can be used to perform work, and in physics this is called "free energy". Because of this flood of incoming sunlight, plants, animals and humans are able to create structures which from a statistical point of view are highly unlikely.

The disorder and statistical probability of the universe is constantly increasing, but because the earth is not a closed system, we are able to create local order, and complex, statistically improbable structures, like the works of Shakespeare, the Mona Lisa and the Internet. The human economy is driven by the free energy which we receive as income from the sun. Money is, in fact, a symbol for free energy, and free energy might be thought of as "negative entropy". There is also a link between free energy and information.[5]

Human society as a superorganism, with the global economy as its digestive system

A completely isolated human being would find it as difficult to survive for a long period of time as would an isolated ant or bee or termite. Therefore it seems correct to regard human society as a superorganism. In the case of humans, the analog of the social insects' nest is the enormous and complex material structure of civilization. It is, in fact, what we call the human economy. It consists of functioning factories, farms, homes, transportation links, water supplies, electrical networks, computer networks and much more.

Almost all of the activities of modern humans take place through the medium of these external "exosomatic" parts of our social superorganism. The terms "exosomatic" and "endosomatic" were coined by the American scientist Alfred Lotka (1880-1949). A lobster's claw is endosomatic; it is part of the lobster's body. The hammer used by a human is exosomatic, like a detachable claw. Lotka spoke of "exosomatic evolution", including in

[4] http://www.theguardian.com/sustainable-business/rio-20-tim-jackson-leaders-green-economy?newsfeed=true
http://www.theguardian.com/sustainable-business/consumerism-sustainability-short-termism

[5] http://www.amazon.com/Information-Theory-And-Evolution-Edition/dp/9814401234

this term not only cultural evolution but also the building up of the material structures of civilization.

The economy associated with the human superorganism "eats" resources and free energy. It uses these inputs to produce local order, and finally excretes them as heat and waste. The process is closely analogous to food passing through the alimentary canal of an individual organism. The free energy and resources that are the inputs of our economy drive it just as food drives the processes of our body, but in both cases, waste products are finally excreted in a degraded form.

Almost all of the free energy that drives the human economy came originally from the sun's radiation, the exceptions being geothermal energy which originates in the decay of radioactive substances inside the earth, and tidal energy, which has its origin in the slowing of the motions of the earth-moon system. However, since the start of the Industrial Revolution, our economy has been using the solar energy stored in of fossil fuels. These fossil fuels were formed over a period of several hundred million years. We are using them during a few hundred years, i.e., at a rate approximately a million times the rate at which they were formed.

The present rate of consumption of fossil fuels is more than 14 terawatts and, if used at the present rate, fossil fuels would last less than a century. However, because of the very serious threats posed by climate change, human society would be well advised to stop the consumption of coal, oil and natural gas within the next two decades.

The rate of growth of of new renewable energy sources is increasing rapidly. These sources include small hydro, modern biomass, solar, wind, geothermal, wave and tidal energy. There is an urgent need for governments to set high taxes on fossil fuel consumption and to shift subsidies from the petroleum and nuclear industries to renewables. These changes in economic policy are needed to make the prices of renewables more competitive.

The shock to the global economy that will be caused by the end of the fossil fuel era will be compounded by the scarcity of other non-renewable resources, such as metals. While it is true (as neoclassical economists emphasize) that "matter and energy can neither be created nor destroyed", free energy can be degraded into heat, and concentrated deposits of minerals can be dispersed. Both the degradation of free energy into heat and the dispersal of minerals involve increases of entropy.

1.5 Frederick Soddy

One of the first people to call attention to the relationship between entropy and economics was the English radiochemist Frederick Soddy (1877-1956). Soddy won the Nobel Prize for Chemistry in 1921 for his work with Ernest Rutherford demonstrating the transmutation of elements in radioactive decay processes. His concern for social problems then led him to a critical study of the assumptions of classical economics. Soddy believed that there is a close connection between free energy and wealth, but only a very tenuous connection between wealth and money.

Soddy was extremely critical of the system of "fractional reserve banking" whereby

private banks keep only a small fraction of the money that is entrusted to them by their depositors and lend out the remaining amount. He pointed out that this system means that the money supply is controlled by the private banks rather than by the government, and also that profits made from any expansion of the money supply go to private corporations instead of being used to provide social services. Fractional reserve banking exists today, not only in England but also in many other countries. Soddy's criticisms of this practice cast light on the subprime mortgage crisis of 2008 and the debt crisis of 2011.

As Soddy pointed out, real wealth is subject to the second law of thermodynamics. As entropy increases, real wealth decays. Soddy contrasted this with the behavior of debt at compound interest, which increases exponentially without any limit, and he remarked:

"You cannot permanently pit an absurd human convention, such as the spontaneous increment of debt [compound interest] against the natural law of the spontaneous decrement of wealth [entropy]". Thus, in Soddy's view, it is a fiction to maintain that being owed a large amount of money is a form of real wealth.

Frederick Soddy's book, "Wealth, virtual wealth and debt: The solution of the economic paradox", published in 1926 by Allen and Unwin, was received by the professional economists of the time as the quixotic work of an outsider. Today, however, Soddy's common-sense economic analysis is increasingly valued for the light that it throws on the problems of our fractional reserve banking system, which becomes more and more vulnerable to failure as economic growth falters.[6]

Currency reform, and nationalization of banks

Frederick Soddy was writing at a time when England's currency was leaving the gold standard, and in order to replace this basis for the currency, he proposed an index system. Soddy's index was to be based on a standard shopping basket containing household items, such as bread, milk, potatoes and so on. If the price of the items in the basket rose, more currency would be issued by the nationalized central bank. If the price fell, currency would be withdrawn.

Nationalization of banks was proposed by Soddy as a means of avoiding the evils of the fractional reserve banking system. Today we see a revival of the idea of nationalized banks, or local user-owned cooperative banks. The Grameen Bank, founded by Prof. Muhammad Yunus, pioneered the idea of socially-motivated banks for the benefit poor people who would ordinarily be unable to obtain loans. The bank and its founder won a Nobel Peace Prize in 2006.[7]

[6] www.fadedpage.com/link.php?file=20140873-a5.pdf
http://human-wrongs-watch.net/2015/07/08/debt-slavery/

[7] http://www.grameen-info.org/history/
http://www.ibtimes.com/greece-drawing-contingency-plans-nationalize-banks-bring-parallel-currency-report-1868830
http://www.quora.com/Why-were-banks-nationalized-in-India
http://www.bloomberg.com/news/articles/2015-01-28/greek-bank-investors-hammered-as-3-day-slump-wipes-12-billion
http://www.armstrongeconomics.com/archives/30531

1.6 Nicholas Georgescu-Roegen: Ecological Economics

The incorporation of the idea of entropy into economic thought also owes much to the mathematician and economist Nicholas Georgescu-Roegen (1906-1994), the son a Romanian army officer. Georgescu-Roegen's talents were soon recognized by the Romanian school system, and he was given an outstanding education in mathematics, which later contributed to his success and originality as an economist.

Between 1927 and 1930 the young Georgescu studied at the Institute de Statistique in Paris, where he completed an award-winning thesis: "On the problem of finding out the cyclical components of phenomena". He then worked in England with Karl Pearson from 1930 to 1932, and during this period his work attracted the attention of a group of economists who were working on a project called the Harvard Economic Barometer. He received a Rockefeller Fellowship to join this group, but when he arrived at Harvard, he found that the project had been disbanded.

In desperation, Georgescu-Roegen asked the economist Joseph Schumpeter for an appointment to his group. Schumpeter's group was in fact a remarkably active and interesting one, which included the future Nobel laureate Wassely Leontief; and there followed a period of intense intellectual activity during which Georgescu-Roegen became an economist.

Despite offers of a permanent position at Harvard, Georgescu-Roegen returned to his native Romania in the late 1930's and early 1940's in order to help his country. He served as a member of the Central Committee of the Romanian National Peasant Party. His experiences at this time led to his insight that economic activity involves entropy. He was also helped to this insight by Borel's monograph on Statistical Mechanics, which he had read during his Paris period.

Georgescu-Roegen later wrote: "The idea that the economic process is not a mechanical analogue, but an entropic, unidirectional transformation began to turn over in my mind long ago, as I witnessed the oil wells of the Plosti field of both World Wars' fame becoming dry one by one, and as I grew aware of the Romanian peasants' struggle against the deterioration of their farming soil by continuous use and by rains as well. However it was the new representation of a process that enabled me to crystallize my thoughts in describing the economic process as the entropic transformation of valuable natural resources (low entropy) into valueless waste (high entropy)."

After making many technical contributions to economic theory, Georgescu-Roegen returned to this insight in his important 1971 book, "The Entropy Law and the Economic Process" (Harvard University Press), where he outlines his concept of bioeconomics. In a later book, "Energy and Economic Myths" (Pergamon Press, New York, 1976), he offered the following recommendations for moving towards a bioeconomic society:

1. The complete prohibition of weapons production, thereby releasing productive forces

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https://en.wikipedia.org/wiki/Nationalization
http://www.theguardian.com/world/2015/jul/23/beppe-grillo-calls-for-nationalisation-of-italian-banks-and-exit-from-euro
http://dissidentvoice.org/2015/07/whats-wrong-with-our-monetary-system-and-how-to-fix-it/

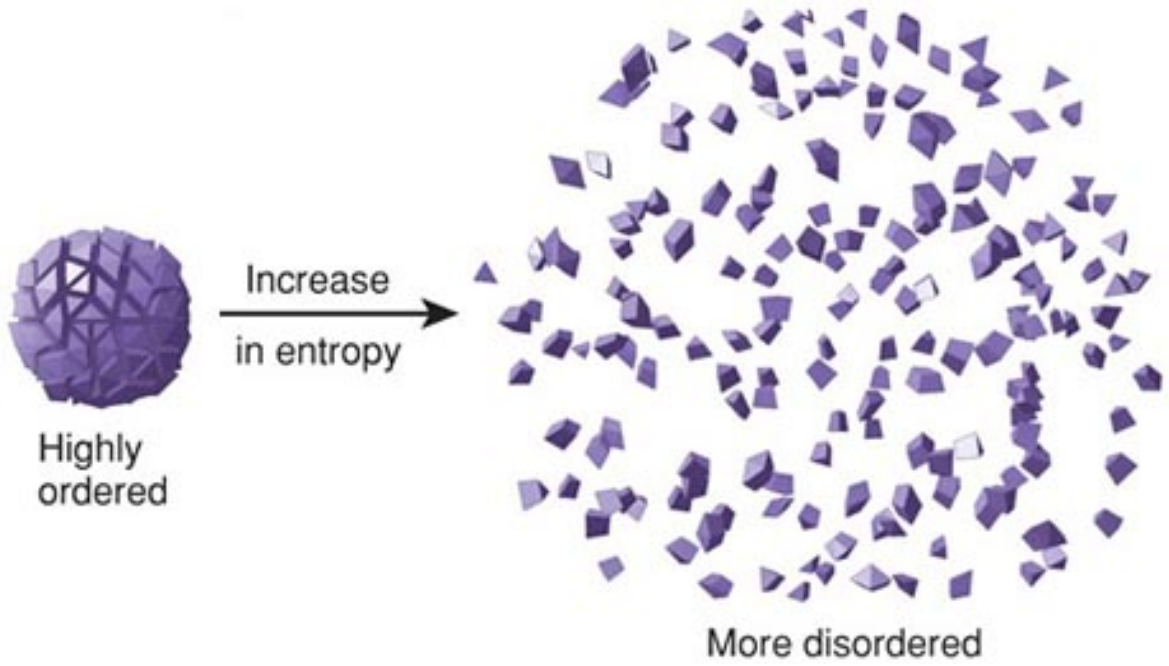

Figure 1.3: **According to the second law of thermodynamics, the entropy of the universe constantly increases. Increase of entropy corresponds to increase of disorder, and also to increase of statistical probability. Living organisms on the earth are able to achieve a high degree of order and highly improbable structures because the earth is not a closed system. It constantly receives free energy (i.e. energy capable of doing work) from the sun, and this free energy can be thought of as carrying thermodynamic information, or "negative entropy". Source: flowchainsensel.wordpress.co,**

Figure 1.4: **Wind, solar, and biomass are three emerging renewable sources of energy. Wind turbines in a rapeseed field in Sandesneben, Germany. Author: Jürgen from Sandesneben, Germany, Wikimedia Commons**

for more constructive purposes;
2. Immediate aid to underdeveloped countries;
3. Gradual decrease in population to a level that could be maintained only by organic agriculture;
4. Avoidance, and strict regulation if necessary, of wasteful energy use;
5. Abandon our attachment to "extravagant gadgetry";
6. "Get rid of fashion";
7. Make goods more durable and repairable; and
8. Cure ourselves of workaholic habits by re-balancing the time spent on work and leisure, a shift that will become incumbent as the effects of the other changes make themselves felt.

Georgescu-Roegen did not believe that his idealistic recommendations would be adopted, and he feared that human society is headed for a crash.

1.7 Herman E. Daly and Kozo Mayumi

Limits to growth

Nicholas Georgescu-Roegen's influence continues to be felt today, not only through his own books and papers but also through those of his students, the distinguished economists Herman E. Daly and Kozo Mayumi, who for many years have been advocating a steady-state

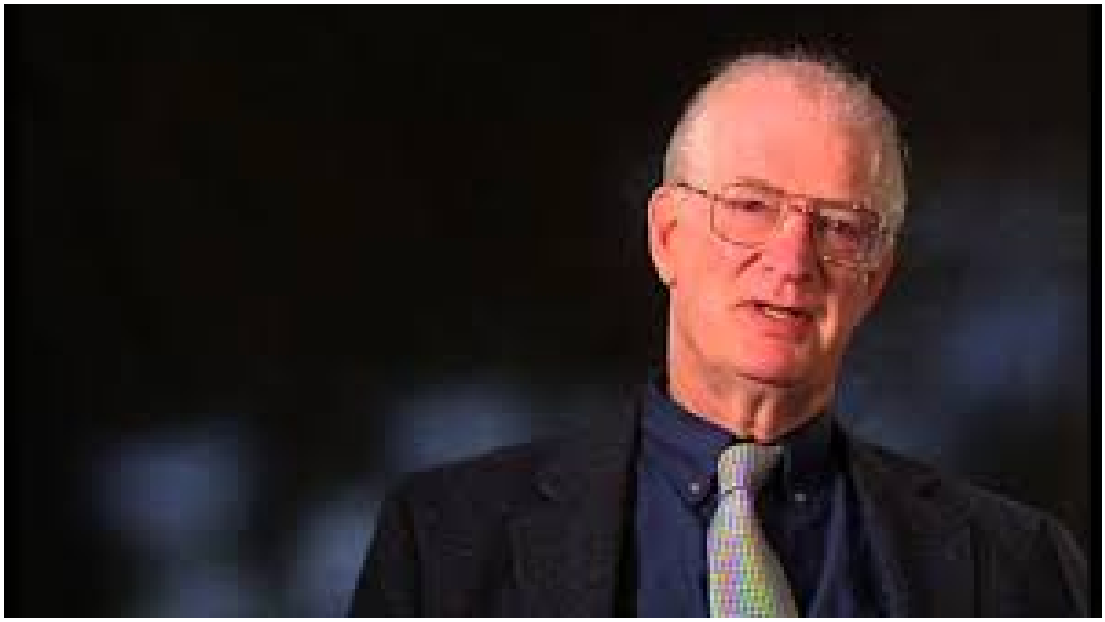

Figure 1.5: **Today, Nicholas Georgescu-Roegen's work for a sustainable steady.state economic system is ably carried forward by his two distinguished students, Professors Herman E. Daly (above) and Kozo Mayumi (below).**

economy. As they point out in their books and papers, it is becoming increasingly apparent that unlimited economic growth on a finite planet is a logical impossibility. However, it is important to distinguish between knowledge, wisdom and culture, which can and should continue to grow, and growth in the sense of an increase in the volume of material goods produced. It is growth in the latter sense that is reaching its limits.

Daly describes our current situation as follows: "The most important change in recent times has been the growth of one subsystem of the Earth, namely the economy, relative to the total system, the ecosphere. This huge shift from an 'empty' to a 'full' world is truly 'something new under the sun'... The closer the economy approaches the scale of the whole Earth, the more it will have to conform to the physical behavior mode of the Earth... The remaining natural world is no longer able to provide the sources and sinks for the metabolic throughput necessary to sustain the existing oversized economy, much less a growing one. Economists have focused too much on the economy's circulatory system and have neglected to study its digestive tract."[8]

In the future, the only way that we can avoid economic collapse is to build a steady-state economy. There exists much literature on how this can be achieved, and these writings ought to become a part of the education of all economists and politicians.

1.8 Antonio Guterres' *State of the Planet* broadcast

Here are some quotations from a December 2, 2020 article by Justin Rowlatt entitled *Humans waging 'suicidal war' on nature - UN chief Antonio Guterres*:

"Humanity is waging what he describes as a 'suicidal' war on the natural world.

"'Nature always strikes back, and is doing so with gathering force and fury,' he told a BBC special event on the environment.

"Mr Guterres wants to put tackling climate change at the heart of the UN's global mission.

"In a speech entitled State of the Planet, he announced that its 'central objective' next year will be to build a global coalition around the need to reduce emissions to net zero.

"Net zero refers to cutting greenhouse gas emissions as far as possible and balancing any further releases by removing an equivalent amount from the

[8] http://dalynews.org/learn/blog/
http://steadystate.org/category/herman-daly/
https://www.youtube.com/watch?v=EN5esbvAt-w
https://www.youtube.com/watch?v=wlR-VsXtM4Y
http://www.imf.org/external/pubs/ft/survey/so/2015/car031315a.htm

atmosphere.

"Mr Guterres said that every country, city, financial institution and company 'should adopt plans for a transition to net zero emissions by 2050'. In his view, they will also need to take decisive action now to put themselves on the path towards achieving this vision.

"The objective, said the UN secretary general, will be to cut global emissions by 45% by 2030 compared with 2010 levels.

"Here's what Mr Guterres demanded the nations of the world do:

- **Put a price on carbon**
- **Phase out fossil fuel finance and end fossil fuel subsidies**
- **Shift the tax burden from income to carbon, and from tax payers to polluters**
- **Integrate the goal of carbon neutrality (a similar concept to net zero) into all economic and fiscal policies and decisions**
- **Help those around the world who are already facing the dire impacts of climate change**

Apocalyptic fires and floods

"It is an ambitious agenda, as Mr Guterres acknowledged, but he said that radical action is needed now.

" 'The science is clear,' Mr Guterres told the BBC, 'unless the world cuts fossil fuel production by 6% every year between now and 2030, things will get worse. Much worse.'

"Climate policies have yet to rise to the challenge, the UN chief said, adding that 'without concerted action, we may be headed for a catastrophic three to five-degree temperature rise this century'.

"The impact is already being felt around the world.

" 'Apocalyptic fires and floods, cyclones and hurricanes are the new normal," he warned.

“ ‘Biodiversity is collapsing. Deserts are spreading. Oceans are choking with plastic waste.’

Moment of truth

“Mr Guterres said the nations of the world must bring ambitious commitments to cut emissions to the international climate conference the UK and Italy are hosting in Glasgow in November next year.

“As well as pressing for action on the climate crisis, he urged nations to tackle the extinction crisis that is destroying biodiversity and to step up efforts to reduce pollution.

“We face, he said, a ”moment of truth”.

“But he does discern some glimmers of hope.

“He acknowledged that the European Union, the US, China, Japan, South Korea and more than 110 other countries have committed to become carbon neutral by the middle of this century.

“He said he wants to see this momentum turned into a movement.

“Technology will help us to reach these targets, Mr Guterres said he believes.

“ ‘The coal business is going up in smoke,’ because it costs more to run most of today’s coal plants than it does to build new renewable plants from scratch, he told the BBC.

“ ‘We must forge a safer, more sustainable and equitable path’, the UN chief concluded.

“He said it is time for this war against the planet to end, adding: ‘We must declare a permanent ceasefire and reconcile with nature.’”

Suggestions for further reading

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Chapter 2

THE CLIMATE EMERGENCY

2.1 Contrasting responses to the pandemic and the climate crisis

There is a remarkable contrast in the way that governments around the world have responded to the COVID-19 pandemic and the way that they have responded to the climate emergency. The pandemic, which indeed represents an extremely grave danger to humanity, has produced a massive global response. Borders have been closed, airlines have become virtually inoperative, industries, restaurants and entertainments have been closed, sporting events have been cancelled or postponed, people have been asked to stay at home and practice social distancing, and the everyday life of citizens around the world has been drastically changed.

By contrast, let us consider the threat that if immediate action is not taken to halt the extraction and use of fossil fuels, irreversible feedback loops will be initiated which will make catastrophic climate change inevitable despite human any human efforts to prevent it.

This threat is even more serious than the COVID-19 pandemic. Climate change could make much of the earth too hot for human life. It could produce a famine involving billions of people, rather than millions.

My own belief is that catastrophic climate change would not lead do the extinction of the human species; but I think that because much of the world would become uninhabitable, the global population of humans would be very much reduced.

How have governments responded to the climate emergency? A minority, for example the Scandinavian countries, have taken appropriate action. Most governments pay lip service to the emergency, but do not take effective action; and a few countries, such as the United States under Donald Trump, Bolsonaro's Brazil, and Saudi Arabia, deny that there is a climate emergency and actively sabotage action.

The world's net response has been totally inadequate. The Keeling Curve, which measures CO_2 concentrations in the atmosphere, continues to rise, and the rate of rising is even increasing.

What is the reason for this remarkable contrast in our response to two serious emergencies? We see clearly and respond to what is close to us, and are relatively indifferent to what is far away. We hear of people dying every day from the COVID-19 pandemic, and there is a danger that as many as 100 million people could die before it is over.

By contrast, although immediate climate action is needed today to avoid disaster, the worst consequences of climate change lie in the long-term future. Old people, like me, will not live to see massive deaths from starvation and overheating.

However, we have a responsibility to our children and grandchildren, and to all future generations. A large-scale global famine could occur by the middle of the present century, and children who are alive today could experience it.

2.2 Recovery from the pandemic offers climate action opportunities

When the COVID-19 pandemic is over, governments will be faced by the task of repairing the enormous economic damage that it has caused. The situation will be similar to the crisis that faced US President Franklin D. Roosevelt when he took office during the Great Depression of the 1930s. Roosevelt, encouraged by John Maynard Keynes, used federal funds to build much-needed infrastructure around the United States. His programs, the New Deal, ended the Great Depression in his country.

Today, the concept of a similar Green New Deal is being put forward globally. This concept visualizes government-sponsored programs aimed at simultaneously creating both jobs and urgently-needed renewable energy infrastructure. The Green New Deal programs could be administered in such a way as to correct social injustices.

2.3 Quick action is needed to save the long-term future

The worst effects of catastrophic climate change lie in the distant future, a century or even many centuries from the present; but disaster can only be avoided if quick action is taken. The nations of the world must act immediately to reduce and eventually stop the use of fossil fuels and the destruction of forests. If decisive action is not taken within the next few decades, feedback loops will make human intervention useless. These feedback loops include the albedo effect, the methane hydrate feedback loop, and the fact as tropical forests become drier, they become vulnerable to fires ignited by lightning. These fires accelerate the drying, and thus a feed-back loop is formed.

As time passes, and as the disastrous consequences of climate change become more apparent, the political will required for action will increase; but by that time it may be too late. We are rapidly approaching several crucial tipping points.

At present, the average global rate of use of primary energy is roughly 2 kW_t per person.

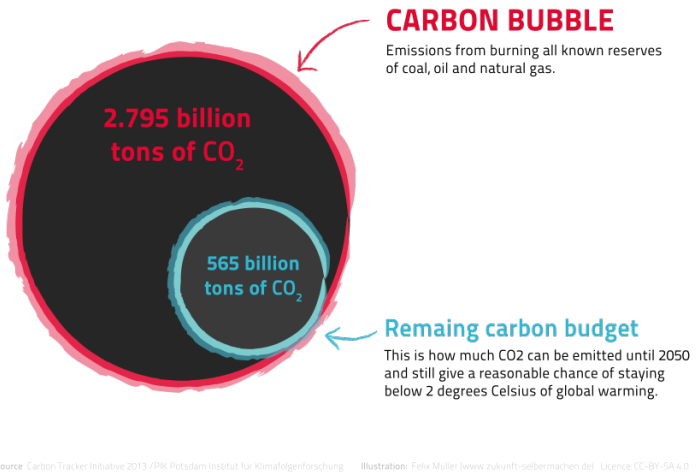

Figure 2.1: **The Carbon Bubble according to data by the Carbon Tracker Initiative 2013. In order to avoid tipping points that will make human attempts to avoid catastrophic climate change useless, we must leave most of the known fossil fuel reserves in the ground!**

In North America, the rate is 12 kW_t per capita, while in Europe, the figure is 6 kW_t. In Bangladesh, it is only 0.2 kW_t. This wide variation implies that considerable energy savings are possible, through changes in lifestyle, and through energy efficiency.

2.4 Is the transition to 100% renewable energy possible?

If we ask whether the transition to 100% renewable energy is possible, the answer is very simple: It is not only possible; it is inevitable! This is because the supply of fossil fuels is finite, and at the present rate of use they will be exhausted in less than a century. While the transition to 100% renewables is inevitable, the vitally important point to remember is that if we are to avoid disaster, the transition must come quickly.

	Reserves	2005 rate of use	Years remaining
Coal	780 TWy	3.5 TW	217 years
Oil	250 TWy	6.0 TW	42 years
Natural gas	250 TWy	3.7 TW	68 years
Total	1260 TWy	13.2 TW	(95 years)

Year	Demand	Population	Per Capita
1980	9.48 TW	4.45 bil.	2.13 kW
1985	10.3 TW	4.84 bil.	2.11 kW
1990	11.6 TW	5.99 bil.	2.20 kW
1995	12.3 TW	5.68 bil.	2.16 kW
2003	14.1 TW	6.30 bil.	2.23 kW
2010	17.1 TW	6.84 bil.	2.50 kW
2015	18.9 TW	7.23 bil.	2.58 kW
2020	20.5 TW	7.61 bil.	2.70 kW
2025	22.3 TW	7.91 bil.	2.82 kW
2030	24.2 TW	8.30 bil.	2.93 kW

In this book, we will use kilowatts (kW), megawatts (MW) and terawatts (TW) as the units in which we discuss the rate of use of energy. A megawatt is equal to a thousand kilowatts or a million watts. A terawatt is equal to a thousand megawatts, or a million kilowatts or a billion (1,000,000,000) watts. A citizen of the European Union uses energy at the rate of about 6 kilowatts, while in North America, the rate of energy use is double that amount. The global average rate of energy use is a little over 2 kilowatts. Since there are now 7.5 billion people in the world, our present rate of energy use is roughly 15 terawatts,

The total available energy from fossil fuels can be measured in terawatt.years (TWy). Rough estimates of global coal reserves of coal, oil and natural gas are given by the table shown above.

The present rate of use of fossil fuels is greater than the 2005 rate shown in the table, and the remaining reserves are smaller than those shown. It is assumed that as oil becomes exhausted, coal will be converted into liquid fuels, as was done in Germany during World War II.

A second table, shown below, illustrates the historical and projected total global energy demand as a function of time between 1980 and 2030. In this slightly out-of-date table, the last year using historical data is 2003, later years being estimates based on projections.

Notice that the per capita energy use is almost constant. Our rapidly growing demand for energy is primarily the result of the world's rapidly growing population of humans. It would be wise to stabilize human populations because of the threat of human-caused ecological catastrophes and the danger of an extremely large-scale famine, involving billions of people rather than millions. Such a famine is threatened because growing populations require a growing food supply, climate changes threaten agriculture through droughts, melting glaciers and loss of agricultural land. The end of the fossil fuel era will also mean the end of high-yield petroleum.based agriculture.

The rate of growth of renewable energy

There is reason for hope that even the high energy demands show in the second table can be met by renewables. The basis of this hope can be found in the extremely high present rate of growth of renewable energy, and in the remarkable properties of exponential growth. According to figures recently released by the Earth Policy Institute, the global installed photovoltaic capacity is currently able to deliver 242,000 megawatts, and it is increasing at the rate of 27.8% per year. Wind energy can now deliver 370,000 megawatts, and it is increasing at the rate of roughly 20% per year.

Because of the astonishing properties of exponential growth, we can calculate that if these growth rates are maintained, renewable energy can give us 24.8 terawatts within only 15 years! This is far more than the world's present use of all forms of energy.

2.5 Renewables are now much cheaper than fossil fuels!

According to an article written by Megan Darby and published in *The Guardian* on 26 January, 2016, "Solar power costs are tumbling so fast the technology is likely to fast outstrip mainstream energy forecasts.

"That is the conclusion of Oxford University researchers, based on a new forecasting

model published in Research Policy[1].

"Commercial prices have fallen by 58% since 2012 and by 16

"Since the 1980s, panels to generate electricity from sunshine have got 10% cheaper each year. That is likely to continue, the study said, putting solar on course to meet 20% of global energy needs by 2027.' '

Solar energy

Unlike the burning of fossil fuels, renewables like solar energy do not release pollutants into the atmosphere. In China. public opinion has shifted in favor of renewables because of air pollution in cities.

Photovoltaic cells

The price of solar photovoltaic panels has declined 99 percent over the last four decades, from $74 a watt in 1972 to less than 70 cents a watt in 2014.

Between 2009 and 2014, solar panel prices dropped by three fourths, helping global PV installations grow 50 percent per year.

Deutsche Bank notes that as of early 2014, solar PV was already competitive with average residential, commercial or industrial electricity rates in 14 countries, and in California - even without subsidies. By late 2014 there were nearly 600,000 individual PV systems in the United States, almost twice as many as in 2012. This number may well pass 1 million in 2016.

In 2013, just 12 percent of U.S homebuilders offered solar panels as an option for new single-family homes. More than half of them anticipate doing so by 2016. Four of the top five U.S. home construction firms - DR Horton, Lennar Corp, PulteGroup and KB Home - now automatically include solar panels on every new house in certain markets.

In 2007 there were only 8,000 rooftop solar installations in coal-heavy Australia; now there are over a million.

Saudi Arabia has 41,000 megawatts of solar PV operating, under construction and planned - enough to generate up to two thirds of the country's electricity.

For the roughly 1.3 billion people without access to electricity, it is now often cheaper and more efficient simply to install solar panels rooftop-by-rooftop than to build a central power plant and transmission infrastructure.

Wind energy

Over the past decade, world wind power capacity grew more than 20 percent a year, its increase driven by its many attractive features, by public policies supporting its expansion, and by falling costs.

[1] http://www.sciencedirect.com/science/article/pii/S0048733315001699

By the end of 2014, global wind generating capacity totaled 369,000 megawatts, enough to power more than 90 million U.S. homes. Wind currently has a big lead on solar PV, which has enough worldwide capacity to power roughly 30 million U.S. homes.

China is now generating more electricity from wind farms than from nuclear plants, and should have little trouble meeting its official 2020 wind power goal of 200,000 megawatts. For perspective, that would be enough to satisfy the annual electricity needs of Brazil.

In nine U.S. states, wind provides at least 12 percent of electricity. Iowa and South Dakota are each generating more than one quarter of their electricity from wind.

In the Midwestern United States, contracts for wind power are being signed at a price of 2.5 cents per kilowatt-hour (kWh), which compares with the nationwide average grid price of 10-12 cents per kWh.

Although a wind farm can cover many square miles, turbines occupy little land. Coupled with access roads and other permanent features, a wind farm's footprint typically comes to just over 1 percent of the total land area covered by the project.

Wind energy yield per acre is off the charts. For example, a farmer in northern Iowa could plant an acre in corn that would yield enough grain to produce roughly $1,000 worth of fuel-grade ethanol per year, or the farmer could put on that same acre a turbine that generates $300,000 worth of electricity per year. Farmers typically receive $3,000 to $10,000 per turbine each year in royalties. As wind farms spread across the U.S. Great Plains, wind royalties for many ranchers will exceed their earnings from cattle sales.

The problem of intermittency

Many forms of renewable energy encounter the problem of intermittency. For example, on windy days, Denmark's windmills generate more than enough electricity to meet the needs of the country, but on days when the wind is less strong, the electrical energy generated is insufficient. Denmark solves this problem by selling surplus electrical power to Germany on windy days, and buying power from hydroelectric-rich Norway on less windy days.

The problem of intermittency can alternatively be solved by pumping water to uphill reservoirs when the wind is strong, and letting the stored water drive turbines when the wind is weak. The problem of intermittency can also be solved with lithium ion storage batteries, by splitting water into hydrogen and oxygen, or by using other types of fuel cells.

Developing countries: No need for grids

When cell phones came into general use, developing countries with no telephone networks were able to use the new technology through satellites, thus jumping over the need for country-wide telephone lines. Similarly, village solar or wind installations in the developing countries can supply power locally, bypassing the need for a grid.

2.6 An economic tipping point

Renewables are now cheaper than fossil fuels

Solar energy and wind energy have recently become cheaper than fossil fuels. Thus a tipping point has been passed. From now on, despite frantic efforts of giant fossil fuel corporations to prevent it from happening, the transition to 100% renewable energy will be driven by economic forces alone.

Subsidies to the fossil fuel industry

http://www.imf.org/en/News/Articles/2015/09/28/04/53/sonew070215a
http://priceofoil.org/fossil-fuel-subsidies/

2.7 An unprecedented investment opportunity

Investment in electric vehicles

On July 5, 2017, the Volvo Car Group made the following announcement: [2]

"Volvo Cars, the premium car maker, has announced that every Volvo it launches from 2019 will have an electric motor, marking the historic end of cars that only have an internal combustion engine (ICE) and placing electrification at the core of its future business.

"The announcement represents one of the most significant moves by any car maker to embrace electrification and highlights how over a century after the invention of the internal combustion engine electrification is paving the way for a new chapter in automotive history.

"'This is about the customer,' said Håkan Samuelsson, president and chief executive. 'People increasingly demand electrified cars and we want to respond to our customers' current and future needs. You can now pick and choose whichever electrified Volvo you wish.'

"Volvo Cars will introduce a portfolio of electrified cars across its model range, embracing fully electric cars, plug in hybrid cars and mild hybrid cars.

"It will launch five fully electric cars between 2019 and 2021, three of which will be Volvo models and two of which will be high performance electrified cars from Polestar, Volvo Cars' performance car arm. Full details of these models will be announced at a later date."

The electric vehicle investment opportunity was also illustrated by the 2017 vote of Germany's Bundesrat to ban the manufacture of internal combustion engines after 2030 [3].

The article announcing the vote adds that "It's a strong statement in a nation where the auto industry is one of the largest sectors of the economy; Germany produces more

[2] https://www.media.volvocars.com/global/en-gb/media/pressreleases/210058/volvo-cars-to-go-all-electric

[3] https://arstechnica.com/cars/2016/10/germanys-bundesrat-votes-to-ban-the-internal-combustion-engine-by-2030/

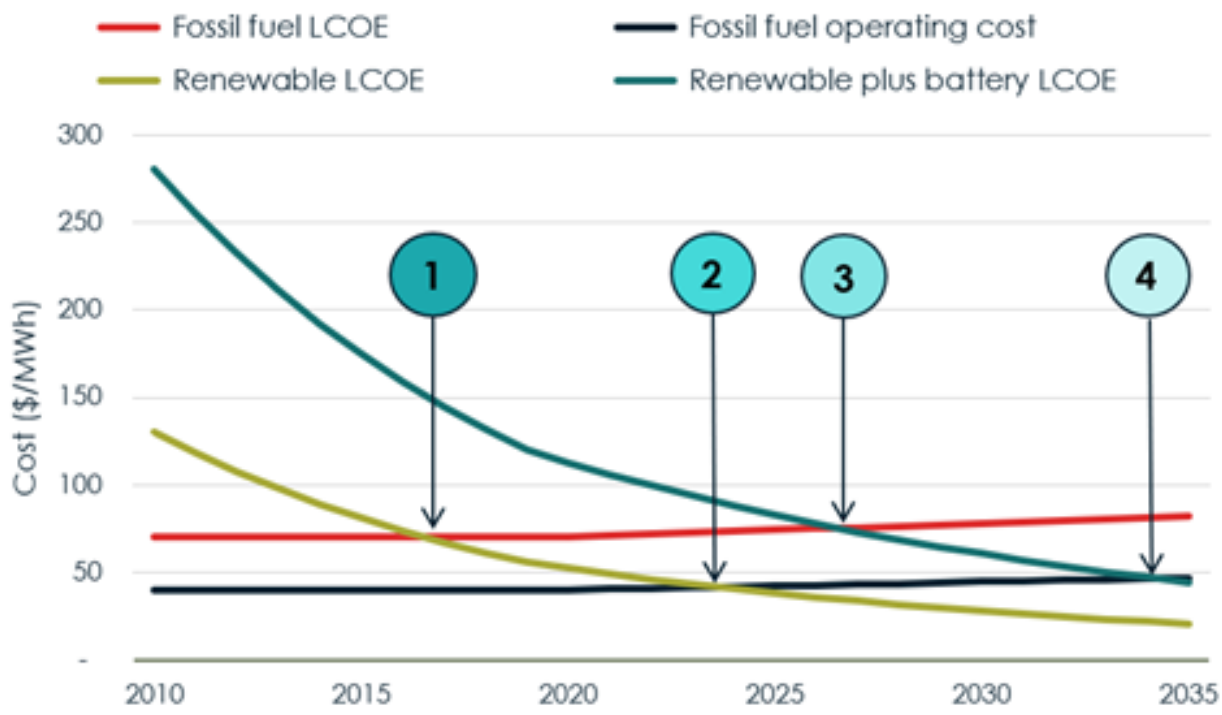

Figure 2.2: **Renewables are now cheaper than fossil fuels. LCOE stands for "Levalized Cost Of Energy", a measure of the average net present cost of electricity generation for a generating plant over its lifetime.**


STOP BEING
A FOSSIL
FUEL


THE CLIMATE IS
CHANGING
WHY AREN'T WE?


WE CAN build a better tomorrow, today
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automobiles than any other country in Europe and is the third largest in the world. The resolution passed by the Bundesrat calls on the European Commission (the executive arm of the European Union) to 'evaluate the recent tax and contribution practices of Member States on their effectiveness in promoting zero-emission mobility,' which many are taking to mean an end to the lower levels of tax currently levied on diesel fuel across Europe."

France plans to end the sale of vehicles powered by gasoline and diesel by 2040, environment minister Nicolas Hulot announced recently.

Hulot made the announcement on Thursday, June 13, 2017, in Paris as he launched the country's new Climate Plan to accelerate the transition to clean energy and to meet its targets under the Paris climate agreement.

To ease the transition, Hulot said the French government will offer tax incentives to replace fossil-fuel burning cars with clean alternatives.

Furthermore, the government of India has recently announced its intention to only nave electric vehicles by 2030[4]. This hugely ambitious plan was announced during the 2017 Confederation of Indian Industry Annual Session. Besides the avoidance of climate change, which might make many regions of India uninhabitable, the motive for replacing 28 million combustion engine vehicles by electric ones was the severe air pollution from which India suffers. Severe air pollution also motivates efforts by the government of China to promote the transition to electric vehicles.

The governments of Norway and the Netherlands have taken steps towards banning the internal combustion engine[5]. Both the upper and lower houses of the Netherlands' government voted to ban cars driven by internal combustion engines by 2025, the same year in which Norway plans to sell nothing but zero-emission vehicles.

In a report commissioned by the investment bankers Cowan & Co, managing director and senior research analyst Jeffrey Osborne, predicted that electric vehicles will cost less than gasoline-powered cars by the early- to mid-2020s due to falling battery prices as well as the costs that traditional carmakers will incur as they comply to new fuel-efficiency standards. Osbourne pointed out that a number of major car brands are hopping onto the electric bandwagon to compete in a space carved out by industry disrupter, Tesla.

"We see the competitive tides shifting in 2019 and beyond as European [car makers] roiled by the diesel scandal and loss of share to Tesla in the high margin luxury segment step on the gas and accelerate the pace of EV introductions", he wrote.

Bloomberg New Energy Finance reported similar predictions: "Falling battery costs will mean electric vehicles will also be cheaper to buy in the U.S. and Europe as soon as 2025," the report said. "Batteries currently account for about half the cost of EVs, and their prices will fall by about 77 percent between 2016 and 2030."

In October, 2017, General Motors unveiled plans to roll out 20 new entirely electric car models by 2023, with two of the new EVs coming out in the next 18 months. Meanwhile, Ford announced the creation of "Team Edison," intended to accelerate the company's EV

[4]https://www.greentechmedia.com/articles/read/what-country-will-become-the-first-to-ban-internal-combustion-cars

[5]http://www.prnewswire.com/news-releases/the-dutch-revolution-in-smart-charging-of-electric-vehicles-597268791.html

development and partnership work. The name, is "seemingly in direct response to Elon Musk's Tesla, which recently surpassed Ford's market capitalization."

Tesla's Chairman, highly successful inventor and entrepreneur Elon Musk, has made massive investments in factories manufacturing electric vehicles, improved lithium ion storage cells, and photovoltaic panels, as will be discussed in Chapter 2.

Investment in wind turbine energy

In Denmark, the wind turbine industry contributes substantially to the country's positive balance of payments. According to Wikipedia, "The Danish wind turbine industry is the world's largest. Around 90% of the national output is exported, and Danish companies accounted for 38% of the world turbine market in 2003, when the industry employed some 20,000 people and had a turnover of around 3 billion euro."

Denmark's two largest wind turbine manufacturers are Vestas and Simiens Wind Power. Vestas employs more that 21000 people globally. In February 2016, Vestas got its largest order of 1,000 MW (278 x 3.6 MW) for the Fosen project near Trondheim in Norway. It costs DKK 11 billion, and should deliver 3.4 TWh per year.

In 2015 Siemens Wind had a combined market share of 63% of European offshore wind turbines (nearly 75% in 2009 by capacity and number). In 2011, Siemens Wind Power had 6.3% share of the world wind turbine market, and was the second largest in 2014.

In many countries, including Australia, Canada, Denmark, Germany, India, The Netherlands, United Kingdom, and United States, wind turbine cooperatives have sprung up. In these cooperatives, communities share the costs and profits of wind turbine projects. For example, the Hepburn Wind Project in Victoria, Australia, owns two 2MW wind turbines which produce enough power for 2,300 households.

Investment in solar energy

Global retinues from solar photovoltaic installations are expected to reach $1.2 trillion between the present and 2024 according to a recent article[6]

Another article[7] states that "The global electric power industry is evolving into a model that offers more diversity, both in terms of generation and in the ownership of generation assets, and solar PV is one technology at the head of this change. Following years of unsustainable pricing and oversupply, demand for solar PV systems has finally caught up, with 2015 expected to be the year when the global solar PV market shifts and starts to compete with other technologies. According to a recent report from Navigant Research, global revenue from solar PV installations is expected to total more than $1.2 trillion from 2015 to 2024."

[6]https://cleantechnica.com/2016/01/25/global-revenue-solar-pv-installations-expected-reach-1-2-trillion/

[7]http://www.navigantresearch.com/newsroom/global-revenue-from-solar-pv-installations-is-expected-to-total-more-than-1-2-trillion-from-2015-to-2024

2.8 For creating jobs, renewables beat fossil fuels

Here are some excerpts from a 2016 report issued by the Solar Foundation:

- One out of every 50 new jobs added in the United States in 2016 was created by the solar industry, representing 2 percent of all new jobs.
- Solar jobs in the United States have increased at least 20 percent per year for the past four years, and jobs have nearly tripled since the first Solar Jobs Census was released in 2010.
- Over the next 12 months, employers surveyed expect one out of every 50 new jobs added in the United States in 2016 was created by the solar industry, representing 2 percent of all new jobs.
- In 2016, the five states with the most solar jobs were California, Massachusetts, Texas, Nevada, and Florida.
- The solar industry added $84 billion to the US GDP in 201t to see total solar industry employment increase by 10 percent to 286,335 solar workers.
- The solar industry added $84 billion to the US GDP in 2016.

2.9 The Stern Review

Background of the Stern Review

The Stern Review on the Economics of Climate Change is a 700 page document commissioned by the government of the United Kingdom and released on 30 October, 2006. The research behind this report was conducted by a team led by Nicolas Stern (Baron Stern of Brentford), chair of the Grantham Research Institute on Climate Change and the Environment.

The Stern Review discusses the catastrophic climate change which will result if prompt action is not taken, and it proposes that 1% of global GDP be used annually to prevent such disasters. In 2014, the global GDP was estimated to be 77.9 trillion dollars, so that the 1% investment in renewable energy recommended by Lord Stern and his research team would have amounted to nearly a trillion dollars.

The Middle East

According to current estimates, 81.5% of the world's proven crude oil reserves are located in OPEC Member Countries, with the bulk of OPEC oil reserves in the Middle East, amounting to 65.5% of the OPEC total.

China

China's large reserves of coal lie near to the surface, and are thus very easily accessible. Mining of coal has driven the country's rapid industrial growth, but it has also produced a severe public health problem because of air pollution.

In April, 2017, China's rate of economic growth was 6.9%[8]. This rate of growth, if continued, would mean that China's economy would double every ten years. and increase by a factor of 1024 every century. Obviously this is impossible. Never-ending economic growth on a finite planet is a logical absurdity. China's high economic growth rate, is driven by its use of coal, and this must quickly stop if ecological disaster is to be avoided.

India

The MIT Technology Review recently published an important article entitled *India's Energy Crisis*[9].

The article makes alarming reading in view of the world's urgent need to make a very rapid transition from fossil fuels to 100% renewable energy. We must make this change quickly in order to avoid a tipping point beyond which catastrophic climate change will be unavoidable.

The MIT article states that "Since he took power in May, 2014, Prime Minister Narendra Modi has made universal access to electricity a key part of his administration's ambitions. At the same time, he has pledged to help lead international efforts to limit climate change. Among other plans, he has promised to increase India's total power generating capacity to 175 gigawatts, including 100 gigawatts of solar, by 2022. (That's about the total power generation of Germany.)"

However India plans to expand its industrial economy, and to do this, it is planning to very much increase its domestic production and use of coal. The MIT article continues, pointing out that

However India plans to expand its industrial economy, and to do this, it is planning to very much increase its domestic production and use of coal. The MIT article continues, pointing out that "Such growth would easily swamp efforts elsewhere in the world to curtail carbon emissions, dooming any chance to head off the dire effects of global climate change. (Overall, the world will need to reduce its current annual emissions of 40 billion tons by 40 to 70 percent between now and 2050.) By 2050, India will have roughly 20 percent of the world's population. If those people rely heavily on fossil fuels such as coal to expand the economy and raise their living standards to the level people in the rich world have enjoyed for the last 50 years, the result will be a climate catastrophe regardless of anything the United States or even China does to decrease its emissions. Reversing these trends will require radical transformations in two main areas: how India produces electricity, and how it distributes it."

[8]https://tradingeconomics.com/china/gdp-growth-annual

[9]http://www.technologyreview.com/featuredstory/542091/indias-energy-crisis/

The Indian Minister of Power, Piyush Goyal, is an enthusiastic supporter of renewable energy expansion, but he also supports, with equal enthusiasm, the large-scale expansion of domestic coal production in India.

Meanwhile, the consequences of global warming are being felt by the people of India. For example, last May, a heat wave killed over 1,400 people and melted asphalt streets.[10]

Have India's economic planners really thought about the long-term future? Have they considered the fact that drastic climate change could make India completely uninhabitable?

Russia

According to Wikipedia, "The petroleum industry in Russia is one of the largest in the world. Russia has the largest reserves, and is the largest exporter, of natural gas. It has the second largest coal reserves, the eighth largest oil reserves, and is one of the largest producer of oil. It is the third largest energy user."

One of the difficulties of reducing Russia's fossil fuel production is that the Russian economy depends so heavily on its oil and gas industries. Many European countries also depend on natural gas from Russia for winter heating of homes and workplaces.

North America

Canadian oil sands

Canada's oil-sands deposits contain an amount of carbon comparable to the world's total reserves of conventional oil. Oil is currently being extracted by methods that release four times as much carbon into the atmosphere as is contained in the refined oil from the deposits. Nevertheless, the government of Canada wholeheartedly supports extraction of oil from the tar sands.

The position of the Canadian government has been strongly criticized by leading climate scientist Professor James Hansen. A recent article in *The Guardian*[11], reported him as saying; "To leave our children with a manageable situation, we need to leave the unconventional fuel in the ground. Canada's ministers are acting as salesmen for those people who will gain from the profits of that industry. But I don't think they are looking after the rights and wellbeing of the population as a whole.

"The thing we are facing overall is that the fossil fuel industry has so much money that they are buying off governments. Our democracies are seriously handicapped by the money that is driving decisions in Washington and other capitals."

Fracking in the United States

According to the US Department of Energy (DOE), in 2013 at least two million oil and gas wells in the US have been hydraulically fractured, and that of new wells being drilled,

[10] https://www.rt.com/news/262641-india-heat-wave-killed/

[11] https://www.theguardian.com/environment/2013/may/19/tar-sands-exploitation-climate-scientist

up to 95% are hydraulically fractured. The output from these wells makes up 43% of the oil production and 67% of the natural gas production in the United States.

Because of earthquakes and poisoning of water supplies caused by fracking, this practice has been banned by several states in the US, and nine countries or regions in Europe: France, Bulgaria, Roumania, Germany, The Czech Republic, Luxembourg, Northern Ireland, Spain and Switzerland,

Latin America

Venezuela's Belt of Tar

The Orinoco River Basin in Venezuela contains the world's largest deposit of extra-heavy oil and tar. The amount of carbon contained in this deposit is comparable to the carbon content of all the world's known reserves of conventional oil, and also larger than the carbon contained in Canada's oil sands.

The Belt of Tar follows the line of the Orinoco river. It is approximately 600 kilometers (370 mi) from east to west, and 70 kilometers (43 mi) from north to south, with an area about 55,314 square kilometers (21,357 sq mi). The Orinoco deposit is estimated to contain 1.2 trillion barrels of extra-heavy oil.

The government of Venezuela has no plans for halting extraction from the Belt of Tar. On the contrary, detailed plans have been made for expanded exploitation of the deposit[12].

Extraction of oil in Brazil

According to a recent article in *The Guardian*[13] "The discovery of tens of billions of barrels of oil in fields far off the coast of Rio de Janeiro was billed as one of the biggest finds of this century when it was announced in 2006.

"Many hoped it would deliver a bonanza for education and health and make Brazil one of world's major economies.

"But with the country's biggest energy company, Petrobras, mired in debt and scandal, the low price of oil and the dangers of a second Deepwater Horizon, the viability of this massive undertaking has never been under more scrutiny."

The Brazilian offshore deposits are called "presalt oil", since they lie under a thick layer of salt deposits.

According to the article in *The Guardian*, "Suggestions by climate campaigners that this reservoir of fossil fuel is a 'carbon bomb' that should be left in the ground, are dismissed as hypocrisy."

The article quotes the geologist who discovered the off-shore fields as saying "The big countries of the world today developed without any concern for the environment. The

[12]https://en.wikipedia.org/wiki/PDVSA

[13]https://www.theguardian.com/environment/ng-interactive/2015/jun/25/brazils-gamble-on-deep-water-oil-guanabara-bay

base of US development was the oil in the Gulf of Mexico. The base of the UK's industrial revolution was coal. How can they now say we can't use our own pre-salt?"

The European Union

Coal in Germany and Poland

In 2016, Germany produced 176,100,000 tonnes of coal while Poland produced 131,100,000 tonnes. In the past, Poland experienced severe ecological effects from acid rain due to the burning of coal. Polish forests were destroyed by the effects of acid rain, and the facades of statues and buildings in Krakow and elsewhere were dissolved by the acid. Today the situation is improving, but the two countries are still heavily dependant on coal.

North Sea oil

According to Wikipedia, "The British and Norwegian sections hold most of the remainder of the large oil reserves. It is estimated that the Norwegian section alone contains 54% of the sea's oil reserves and 45% of its gas reserves- More than half of the North Sea oil reserves have been extracted, according to official sources in both Norway and the UK. For Norway, the Norwegian Petroleum Directorate [28] gives a figure of 4,601 million cubic meters of oil (corresponding to 29 billion barrels) for the Norwegian North Sea alone (excluding smaller reserves in Norwegian Sea and Barents Sea) of which 2,778 million cubic meters (60%) has already been produced prior to January 2007. UK sources give a range of estimates of reserves, but even using the most optimistic 'maximum' estimate of ultimate recovery, 76% had been recovered at end 2010.[citation needed] Note the UK figure includes fields which are not in the North Sea (onshore, West of Shetland).

2.10 Major producers of fossil fuels

The top 20 oil-producing nations in 2016

Wikipedia's article entitles *List of countries by oil production* gives information shown in the table below. In the table. which is based on data from the International Energy Agency, production is measured in barrels of oil per day

1	Russia	10,551,497
2	Saudi Arabia	10,460,710
3	United States	8,875,817
4	Iraq	4,451,516
5	Iran	3,990,956
6	China	3,980,650
7	Canada	3,662,694
8	United Arab Emirates	3,106,077
9	Kuwait	2,923,825
10	Brazil	2,515,459
11	Venezuela	2,276,967
12	Mexico	2,186,877
13	Nigeria	1,999,885
14	Angola	1,769,615
15	Norway	1,647,975
16	Kazakhstan	1,595,199
17	Qatar	1,522,902
18	Algeria	1,348,361
19	Oman	1,006,841
20	United Kingdom	939,760

The top 10 coal producing nations in 2016

Wikipedia gives a similar list of coal producing nations. Only the top 10 are shown here, since these countries completely dominate global coal production. In the table, production is measured in millions of tonnes per year.

1	China	3411.0
2	India	692.4
3	United States	660.6
4	Australia	492.8
5	Indonesia	434.0
6	Russia	385.4
7	South Africa	251.3
8	Germany	176.1
9	Poland	131.1
10	Kazakhstan	102.4
	World	7,460.4

The world production of coal is falling. In 2014 it was 8,164.9 tonnes, in 2015, 7,861.1 tonnes, and in 2016 7,460.4 tonnes. Nevertheless, global production of coal remains worryingly high. If catastrophic climate change is to be avoided, it must stop altogether within one or two decades. At the moment the world is still producing roughly 1 tonne of coal per capita each year.

List of countries by natural gas production

Here is a similar table for natural gas. Production is measured in m^3 per year. The final column indicates the date of the data.

1	United States	728,200,000,000	2014
2	Russia	578,700,000,000	2014
3	Iran	438,000,000,000	2017
4	Canada	143,100,000,000	2012
5	Qatar	133,200,000,000	2011
6	Norway	114,700,000,000	2012
7	China	107,200,000,000	2012
8	Saudi Arabia	103,200,000,000	2012
9	Algeria	82,760,000,000	2011
10	Netherlands	80,780,000,000	2012
	World	4,359,000,000,000	2010

2.11 Fossil fuel extraction must stop!

"Leave the oil in the soil! Leave the coal in the hole! Leave the gas under the grass!" That was message of protesters at the 2017 G20 meeting. But from the facts shown in this chapter, we can see that on the whole, fossil fuels are not being left in the ground, where they have to remain if an ecological disaster is to be avoided. On the contrary, the extraction of coal, oil and gas continues almost as though the climate emergency did not exist. Most politicians, with their eyes focused on the present, seem blind to future dangers. They think primarily about the jobs and living standards of their constituents, and about the next election. Meanwhile, the future of human civilization is neglected and remains in peril.[14]

The fact that historically, the highly industrialized nations were primarily responsible for atmospheric CO_2 increases does not excuse the developing countries from their responsibility for saving the future. Today China's coal, India's coal, Venezuela's tar sands and Brazil's pre-salt oil are among the greatest threats, and in these countries as elsewhere, extraction must stop.

We have to wake up! Business as usual cannot continue!

2.12 Permian-Triassic extinction event

The geological record shows five major extinction events.

- Ordovician-Silurian Extinction. around 439 million years ago.

[14]See https://www.theguardian.com/commentisfree/2017/sep/18/enough-tiptoeing-around-lets-make-this-clear-coal-kills-people

- Late Devonian Extinction. 375-360 million years ago.
- Permian-Triassic extinction. 352 million years ago.
- Triassic-Jurassic extinction, 201 million years ago.
- Cretaceous-Paleogene extinction, 66 million years ago.

The most devastating of these was the Permian-Triassic extinction, which occurred 252 million years ago.[15] In the Permian-Triassic extinction, 96% of all marine species and 76% of all terrestrial vertebrates disappeared forever. The cause of this extremely severe event is disputed, but according to one of the most plausible theories it was triggered by a massive volcanic eruption in Siberia, which released enormous amounts of CO_2 into the earth's atmosphere.

The region where massive volcanic eruptions are known to have occurred 252 million years ago called the "Siberian Traps". (The "Traps" part of the name comes from the fact that many of the volcanic rock formations in the region resemble staircases. The Swedish word for staircase is "trapped".) The eruptions continued for about a million years.

Today the area covered is about 2 million square kilometers, roughly equal to western Europe in land area. Estimates of the original coverage are as high as 7 million square kilometers. The original volume of lava is estimated to range from 1 to 4 million cubic kilometers.

The CO_2 released by the Siberian Traps eruption is believed to have caused a global temperature increase of 6^oC, and this was enough to trigger the methane-hydrate feedback loop, which will be discussed below, The earth's temperature is thought to have continued to rise for 85,000 years, finally reaching 15^o above normal.

2.13 Tipping points and feedback loops

A tipping point is usually defined as the threshold for an abrupt and irreversible change[16]. To illustrate this idea, we can think of a book lying on a table. If we gradually push the book towards the edge of the table, we will finally reach a point after which more than half of the weight of the book will not be not supported by the table. When this "tipping point" is passed the situation will suddenly become unstable, and the book will fall to the floor. Analogously, as the earth's climate gradually changes, we may reach tipping points. If we pass these points, sudden instabilities and abrupt climatic changes will occur.

[15] https://www.thomhartmann.com/bigpicture/last-hours-climate-change
The Last Hours of Humanity: Warming the World To Extinction (book), by Thom Hartmann
https://www.amazon.com/Last-Hours-Humanity-Warming-Extinction/dp/1629213640
http://www.mediaite.com/online/leonardo-dicaprio-boosts-thom-hartmann-apocalyptic-global-warming-film-last-hours/

[16] Other definitions of tipping points are possible. A few authors define these as points beyond which change is inevitable, emphasizing that while inevitable, the change may be slow.

Greenland ice cores supply a record of temperatures in the past, and through geological evidence we have evidence of sea levels in past epochs. These historical records show that abrupt climatic changes have occurred in the past.

Timothy Michael Lenton, FRS, Professor of Climate Change and Earth System Science at he University of Exeter, lists the following examples of climatic tipping points:

- Boreal forest dieback
- Amazon rainforest dieback
- Loss of Arctic and Antarctic sea ice (Polar ice packs) and melting of Greenland and Antarctic ice sheets
- Disruption to Indian and West African monsoon
- Formation of Atlantic deep water near the Arctic ocean, which is a component process of the thermohaline circulation.
- Loss of permafrost, leading to potential Arctic methane release and clathrate gun effect

It can be seen from this list that climate tipping points are associated with feedback loops. For example, the boreal forest dieback and the Amazon rainforest dieback tipping points are associated with the feedback loop involving the drying of forests and forest fires, while the tipping point involving loss of Arctic and Antarctic sea ice is associated with the Albedo effect feedback loop. The tipping point involving loss of permafrost is associated with the methane hydrate feedback loop.

Once a positive feedback loop starts to operate in earnest, change may be abrupt.

2.14 Greta Thunberg's TED talk

While political leaders and the older generation have been slow to react to the climate crisis, young people, whose future is at stake, are wide awake and are warning the world that action must be taken immediately if disaster is to be avoided. Massive global demonstrations have been initiated by the teenage activist, Greta Thunberg, who has succeeded where others have failed by speaking with extraordinary clarity, honesty and forcefulness.

Greta was born in Sweden in 2003. Her father, Svante Thunberg, is related to Svante Arrhenius, one of the important pioneers of climate science, and is named after him. Greta's mother was a successful opera singer. Greta Thunberg's strong belief in the urgency of action to prevent catastrophic climate change converted her parents, so that they made changes in their lives. For example, Greta's mother gave up her career as an opera singer because it involved air travel.

In November, 2018, Greta Thunberg gave an impressively clear TEDx talk in Stockholm, the video of which was recently released.[17]. Here is a transcript of the talk.

When I was about 8 years old, I first heard about something called 'climate change' or 'global warming'. Apparently, that was something humans had created by our way of living. I was told to turn off the lights to save energy and to recycle paper to save resources. I remember thinking that it was very strange that humans, who are an animal species among others, could be capable of changing the Earth's climate. Because, if we were, and if it was really happening, we wouldn't be talking about anything else. As soon as you turn on the TV, everything would be about that. Headlines, radio, newspapers: You would never read or hear about anything else. As if there was a world war going on, but no one ever talked about it. If burning fossil fuels was so bad that it threatened our very existence, how could we just continue like before? Why were there no restrictions? Why wasn't it made illegal?

To me, that did not add up. It was too unreal.

So, when I was 11, I became ill, I fell into depression, I stopped talking, and I stopped eating. In two months, I lost about 10 kilos of weight. Later on, I was diagnosed with Asperger's syndrome, OCD and selective mutism. This basically means, I only speak, when I think it is necessary.

Now is one of those moments.

For those of us, who are on the spectrum, almost everything is black or white. We aren't very good at lying and we usually don't enjoy participating in the social games that the rest of you seem so fond of. I think, in many ways, that we autistic are the normal ones and the rest of the people are pretty strange. Especially when it comes to the sustainability crisis: Where everyone keeps saying that climate change is an existential threat and the most important issue of all. And yet, they just carry on like before.

I don't understand that. Because if the emissions have to stop, then we must stop the emissions. To me, that is black or white. There are no gray areas when it comes to survival. Either we go on as a civilization or we don't.

We have to change.

Rich countries like Sweden need to start reducing emissions by at least 15% every year. And that is so that we can stay below a 2 degrees warming target. Yet, as the IPCC has recently demonstrated, aiming instead for 1.5 degrees Celsius would significantly reduce the climate impacts. But we can only imagine what that means for reducing emissions.

You would think the media and every one of our leaders would be talking about nothing else. But they never even mention it.

Nor does anyone ever mentioned the greenhouse gases already locked in the

[17]https://www.dailykos.com/stories/2018/12/16/1819508/-A-Call-to-Action-on-Climate-Change-by-15-year-Old-Greta-Thunberg

system. Nor that air pollution is hiding some warming; so that, when we stop burning fossil fuels, we already have an extra level of warming - perhaps as high as 0.5 to 1.1 degrees Celsius.

Furthermore, does hardly anyone speak about the fact that we are in the midst of the sixth mass extinction: With up to 200 species going extinct every single day. That the extinction rate is today between 1000 and 10,000 times higher than what is seen as normal.

Nor does hardly anyone ever speak about the aspect of equity or climate justice, clearly stated everywhere in the Paris agreement, which is absolutely necessary to make it work on a global scale. That means that rich countries need to get down to zero emissions within 6 to 12 years with today's emission speed. And that is so that people in poorer countries can have a chance to heighten their standard of living by building some of the infrastructures that we have already built, such as roads, schools, hospitals, clean drinking water, electricity, and so on. Because, how can we expect countries like India or Nigeria to care about the climate crisis if we, who already have everything, don't care even a second about it or our actual commitments to the Paris agreement?

So why are we not reducing our emissions? Why are they in fact still increasing? Are we knowingly causing a mass extinction? Are we evil?

No, of course, not. People keep doing what they do because the vast majority doesn't have a clue about the actual consequences for their everyday life. And they don't know that rapid change is required.

We all think we know and we all think everybody knows. But we don't.

Because, how could we? If there really was a crisis, and if this crisis was caused by our emissions, you would at least see some signs. Not just flooded cities. Tens of thousands of dead people and whole nations leveled to piles of torn down buildings. You would see some restrictions.

But no. And no one talks about it. There are no emergency meetings, no headlines, no breaking news. No one is acting as if we were in a crisis.

Even most climate scientists or green politicians keep on flying around the world, eating meat and dairy.

If I live to be 100, I will be alive in the year 2103. When you think about the future today, you don't think beyond the year 2050. By then I will, in the best case, not even have lived half of my life. What happens next? In the year 2078, I will celebrate my 75th birthday. If I have children or grandchildren, maybe they will spend that day with me. Maybe they will ask me about you, the people who were around back in 2018. Maybe they will ask why you didn't do anything while there still was time to act. What we do or don't do right now, will affect my entire life and the lives of my children and grandchildren. What we do or don't do right now, me and my generation can't undo in the future.

So, when school started in August of this year, I decided that this was

enough. I set myself down on the ground outside the Swedish parliament. I school-striked for the climate.

Some people say that I should be in school instead. Some people say that I should study, to become a climate scientist so that I can solve the climate crisis.

But the climate crisis has already been solved. We already have all the facts and solutions. All we have to do is to wake up and change.

And why should I be studying for a future that soon will be no more, when no one is doing anything whatsoever to save that future? And what is the point of learning facts in the school system, when the most important facts given by the finest science of that same school system clearly means nothing to our politicians and our society?

Some people say that Sweden is just a small country and that it doesn't matter what we do. But I think that if a few children can get headlines all over the world just by not coming to school for a few weeks, imagine what we could all do together if we wanted to?

Now we're almost at the end of my talk and this is where people usually people usually start talking about hope. Solar panels, wind power, circular economy, and so on. But I'm not going to do that. We've had 30 years of pep talking and selling positive ideas. And I'm sorry but it doesn't work because if it would have, the emissions would have gone down by now. They haven't.

And yes, we do need hope. Of course, we do. But the one thing we need more than hope is action. Once we start to act, hope is everywhere. So instead of looking for hope, look for action. Then and only then, hope will come today.

Today we use 100 million barrels of oil every single day. There are no politics to change that. There are no rules to keep that oil in the ground. So, we can't save the world by playing by the rules, because the rules have to be changed.

Everything needs to change and it has to start today.

Thank you.

2.15 Only immediate climate action can save the future

Immediate action to halt the extraction of fossil fuels and greatly reduce the emission of CO_2 and other greenhouse gasses is needed to save the long-term future of human civilization and the biosphere.

At the opening ceremony of United Nations-sponsored climate talks in Katowice, Poland, Sir David Attenborough said "Right now, we are facing a man-made disaster of global scale. Our greatest threat in thousands of years. Climate change. If we don't take action, the collapse of our civilizations and the extinction of much of the natural world is on the hori-

Figure 2.3: **Greta Thunberg speaking to a meeting of the European Union.**

zon. The world's people have spoken. Their message is clear. Time is running out. They want you, the decision-makers, to act now."

Antonio Guterres, UN Secretary-General, said climate change was already "a matter of life and death" for many countries. He added that the world is "nowhere near where it needs to be" on the transition to a low-carbon economy.

Swedish student Greta Thunberg, is a 16-year-old who has launched a climate protest movement in her country. She said, in a short but very clear speech after that of UN leader Antonio Guterres: "Some people say that I should be in school instead. Some people say that I should study to become a climate scientist so that I can 'solve the climate crisis'. But the climate crisis has already been solved. We already have all the facts and solutions."

She added: "Why should I be studying for a future that soon may be no more, when no one is doing anything to save that future? And what is the point of learning facts when the most important facts clearly mean nothing to our society?"

Thunberg continued: "Today we use 100 million barrels of oil every single day. There are no politics to change that. There are no rules to keep that oil in the ground. So we can't save the world by playing by the rules. Because the rules have to be changed."

She concluded by saying that "since our leaders are behaving like children, we will have to take the responsibility they should have taken long ago."

2.16 Understatement of existential climate risk

Here are some excerpts from a 44-page report entitled *What Lies Beneath: The Understanding of Existential Climate Risk*, by David Spratt and Ian Dunlop[18]:

[18]https://www.breakthroughonline.org.au/

Three decades ago, when serious debate on human-induced climate change began at the global level, a great deal of statesmanship was on display. There was a preparedness to recognize that this was an issue transcending nation states, ideologies and political parties which had to be addressed pro-actively in the long-term interests of humanity as a whole. This was the case even though the existential nature of the risk it posed was far less clear cut than it is today.

As global institutions, such as the United Nations Framework Convention on Climate Change (UNFCCC) which was established at the Rio Earth Summit in 1992, were developed to take up this challenge, and the extent of change this would demand of the fossil-fuel-dominated world order became clearer, the forces of resistance began to mobilize. Today, as a consequence, and despite the diplomatic triumph of the 2015 Paris Agreement, the debate around climate change policy has never been more dysfunctional, indeed Orwellian.

In his book 1984, George Orwell describes a double-think totalitarian state where most of the population accepts "the most flagrant violations of reality, because they never fully grasped the enormity of what was demanded of them, and were not sufficiently interested in public events to notice what was happening. By lack of understanding they remained sane."

Orwell could have been writing about climate change and policymaking. International agreements talk of limiting global warming to 1.5-2 degrees Celsius (^{o}C), but in reality they set the world on a path of 3-5^{o}C of warming. Goals are reaffirmed, only to be abandoned. Coal is "clean". Just 1^{o}C of warming is already dangerous, but this cannot be admitted. The planetary future is hostage to myopic national self-interest. Action is delayed on the assumption that as yet unproven technologies will save the day, decades hence. The risks are existential, but it is "alarmist" to say so.

A one-in-two or one-in-three chance of missing a goal is normalized as reasonable. Moral hazard permeates official thinking, in that there is an incentive to ignore the risks in the interests of political expediency.

Climate policymaking for years has been cognitively dissonant, "a flagrant violation of reality". So it is unsurprising that there is a lack of understanding amongst the public and elites of the full measure of the climate challenge. Yet most Australians sense where we are heading: three-quarters of Australians see climate change as catastrophic risk, and half see our way of life ending within the next 100 years.

Politics and policymaking have norms: rules and practices, assumptions and boundaries, that constrain and shape them. In recent years, the previous norms of statesmanship and long-term thinking have disappeared, replaced by an obsession with short-term political and commercial advantage. Climate policymaking is no exception. Since 1992, short-term economic interest has trumped environmental and future human needs.

The world today emits 50% more carbon dioxide (CO_2) from the consumption of energy than it did 25 years ago, and the global economy has more than doubled in size. The UNFCCC strives "to enable economic development to proceed in a sustainable manner", but every year humanity's ecological footprint becomes larger and less sustainable. Humanity now requires the biophysical capacity of 1.7 Earths annually as it rapidly chews up natural capital.

A fast, emergency-scale transition to a post-fossil fuel world is absolutely necessary to address climate change. But this is excluded from consideration by policymakers because it is considered to be too disruptive. The orthodoxy is that there is time for an orderly economic transition within the current short-termist political paradigm. Discussion of what would be safe - less warming than we presently experience - is non-existent. And so we have a policy failure of epic proportions.

Policymakers, in their magical thinking, imagine a mitigation path of gradual change to be constructed over many decades in a growing, prosperous world. The world not imagined is the one that now exists: of looming financial instability; of a global crisis of political legitimacy and "fake news"; of a sustainability crisis that extends far beyond climate change to include all the fundamentals of human existence and most significant planetary boundaries (soils, potable water, oceans, the atmosphere, biodiversity, and so on); and of severe global energy-sector dislocation.

In anticipation of the upheaval that climate change would impose upon the global order, the IPCC was established by the United Nations (UN) in 1988, charged with regularly assessing the global consensus on climate science as a basis for policymaking. The IPCC Assessment Reports (AR), produced every five-to-eight years, play a large part in the public framing of the climate narrative: new reports are a global media event.

AR5 was produced in 2013-14, with AR6 due in 2022. The IPCC has done critical, indispensable work of the highest standard in pulling together a periodic consensus of what must be the most exhaustive scientific investigation in world history.

It does not carry out its own research, but reviews and collates peer-reviewed material from across the spectrum of this incredibly complex area, identifying key issues and trends for policymaker consideration. However, the IPCC process suffers from all the dangers of consensus-building in such a wide-ranging and complex arena. For example, IPCC reports, of necessity, do not always contain the latest available information. Consensus-building can lead to "least drama", lowest-common-denominator outcomes, which overlook critical issues. This is particularly the case with the "fat-tails" of probability distributions, that is, the high-impact but lower-probability events where scientific knowledge is more limited.

Vested-interest pressure is acute in all directions; climate denialists accuse the IPCC of alarmism, whereas many climate action proponents consider the

IPCC to be far too conservative. To cap it all, the IPCC conclusions are subject to intense political oversight before being released, which historically has had the effect of substantially watering-down sound scientific findings.

These limitations are understandable, and arguably were not of overriding importance in the early period of the IPCC. However, as time has progressed, it is now clear that the risks posed by climate change are far greater than previously anticipated. We have moved out of the twilight period of much talk, but relatively limited climate impacts, into the harsh light of physically-evident existential threats. Climate change is now turning nasty, as we have witnessed recently in the North America, East and South Asia, the Middle East and Europe, with record-breaking heatwaves and wildfires, more intense flooding and more damaging hurricanes.

The distinction between climate science and risk is the critical issue, for the two are not the same. Scientific reticence - a reluctance to spell out the full risk implications of climate science in the absence of perfect information - has become a major problem. Whilst this is understandable, particularly when scientists are continually criticized by denialists and political apparatchiks for speaking out, it is extremely dangerous given the fat-tail risks of climate change. Waiting for perfect information, as we are continually urged to do by political and economic elites, means it will be too late to act. Time is not on our side. Sensible risk management addresses risk in time to prevent it happening, and that time is now.

Irreversible, adverse climate change on the global scale now occurring is an existential risk to human civilization. Many of the world's top climate scientists - Kevin Anderson, James Hansen, Michael E. Mann, Michael Oppenheimer, Naomi Oreskes, Stefan Rahmstorf, Eric Rignot, Hans Joachim Schellnhuber, Kevin Trenberth and others - who are quoted in this report well understand these implications and are forthright about their findings, where we are heading, and the limitations of IPCC reports.

This report seeks to alert the wider community and business and political leaders to these limitations and urges changes to the IPCC approach, to the wider UNFCCC negotiations, and to national policymaking. It is clear that existing processes will not deliver the transformation to a carbon-negative world in the limited time now available. We urgently require a re-framing of scientific research within an existential risk-management framework. This requires special precautions that go well beyond conventional risk management. Like an iceberg, there is great danger in "what lies beneath".

Existential Risk to Human Civilization

In 2016, the World Economic Forum survey of the most impactful risks for the years ahead elevated the failure of climate change mitigation and adaptation to the top of the list, ahead of weapons of mass destruction, ranking second, and

water crises, ranking third. By 2018, following a year characterized by high-impact hurricanes and extreme temperatures, extreme-weather events were seen as the single most prominent risk. As the survey noted: "We have been pushing our planet to the brink and the damage is becoming increasingly clear."

Climate change is an existential risk to human civilization: that is, an adverse outcome that would either annihilate intelligent life or permanently and drastically curtail its potential.

Temperature rises that are now in prospect, after the Paris Agreement, are in the range of 3-5 ^{o}C. At present, the Paris Agreement voluntary emission reduction commitments, if implemented, would result in planetary warming of 3.4 ^{o}C by 2100, without taking into account "long-term" carbon- cycle feedbacks. With a higher climate sensitivity figure of 4.5 ^{o}C, for example, which would account for such feedbacks, the Paris path would result in around 5 ^{o}C of warming, according to a MIT study.

A study by Schroeder Investment Management published in June 2017 found - after taking into account indicators across a wide range of the political, financial, energy and regulatory sectors - the average temperature increase implied for the Paris Agreement across all sectors was 4.1 ^{o}C.

Yet 3 ^{o}C of warming already constitutes an existential risk. A 2007 study by two US national security think-tanks concluded that 3 ^{o}C of warming and a 0.5 meter sea-level rise would likely lead to "outright chaos" and "nuclear war is possible", emphasizing how "massive non-linear events in the global environment give rise to massive nonlinear societal event".

The Global Challenges Foundation (GCF) explains what could happen: "If climate change was to reach 3 ^{o}C, most of Bangladesh and Florida would drown, while major coastal cities - Shanghai, Lagos, Mumbai - would be swamped, likely creating large flows of climate refugees. Most regions in the world would see a significant drop in food production and increasing numbers of extreme weather events, whether heat waves, floods or storms. This likely scenario for a 3 ^{o}C rise does not take into account the considerable risk that self-reinforcing feedback loops set in when a certain threshold is reached, leading to an ever increasing rise in temperature. Potential thresholds include the melting of the Arctic permafrost releasing methane into the atmosphere, forest die-back releasing the carbon currently stored in the Amazon and boreal forests, or the melting of polar ice caps that would no longer reflect away light and heat from the sun."

Warming of 4 ^{o}C or more could reduce the global human population by 80% or 90%, and the World Bank reports "there is no certainty that adaptation to a 4 ^{o}C world is possible."

Prof. Kevin Anderson says a 4 ^{o}C future "is incompatible with an organized global community, is likely to be beyond 'adaptation', is devastating to the majority of ecosystems, and has a high probability of not being stable".

This is a commonly-held sentiment amongst climate scientists. A recent

study by the European Commission's Joint Research Centre found that if the global temperature rose 4 ^{o}C, then extreme heatwaves with "apparent temperatures" peaking at over 55 ^{o}C will begin to regularly affect many densely populated parts of the world, forcing much activity in the modern industrial world to stop. ("Apparent temperatures" refers to the Heat Index, which quantifies the combined effect of heat and humidity to provide people with a means of avoiding dangerous conditions.)

In 2017, one of the first research papers to focus explicitly on existential climate risks proposed that "mitigation goals be set in terms of climate risk category instead of a temperature threshold", and established a "dangerous" risk category of warming greater than 1.5 ^{o}C, and a "catastrophic" category for warming of 3 ^{o}C or more. The authors focussed on the impacts on the world's poorest three billion people, on health and heat stress, and the impacts of climate extremes on such people with limited adaptation resources. They found that a 2 ^{o}C warming "would double the land area subject to deadly heat and expose 48% of the population (to deadly heat). A 4 ^{o}C warming by 2100 would subject 47% of the land area and almost 74% of the world population to deadly heat, which could pose existential risks to humans and mammals alike unless massive adaptation measures are implemented."

A 2017 survey of global catastrophic risks by the Global Challenges Foundation found that: "In high-end [climate] scenarios, the scale of destruction is beyond our capacity to model, with a high likelihood of human civilization coming to an end."

84% of 8000 people in eight countries surveyed for the Foundation considered climate change a "global catastrophic risk".

Existential risk may arise from a fast rate of system change, since the capacity to adapt, in both the natural and human worlds, is inversely proportional to the pace of change, amongst other factors. In 2004, researchers reported on the rate of warming as a driver of extinction...

At 4 ^{o}C of warming "the limits for adaptation for natural systems would largely be exceeded throughout the world".

Ecological breakdown of this scale would ensure an existential human crisis. By slow degrees, these existential risks are being recognized. In May 2018, an inquiry by the Australian Senate into national security and global warming recognized "climate change as a current and existential national security risk... defined as 'one that threatens the premature extinction of Earth-originating intelligent life or the permanent and drastic destruction of its potential for desirable future development'".

In April 2018, the Intelligence on European Pensions and Institutional Investment think-tank warned business leaders that "climate change is an existential risk whose elimination must become a corporate objective".

However the most recent IPCC Assessment Report did not consider the issue. Whilst the term "risk management" appears in the 2014 IPCC Synthe-

sis Report fourteen times, the terms "existential" and "catastrophic" do not appear...

2.17 The 2018 IPCC report

Excerpts from an article summarizing the report

Here are excerpts from an article entitled **UN Experts Warn of 'Climate Catastrophe' by 2040** by Jesica Corbett. The article was published in Common Dreams on Monday, October 8, 2018.[19]:

"The climate crisis is here and already impacting the most vulnerable," notes 350.org's program director. "Staying under 1.5^{o}C is now a matter of political will."

Underscoring the need for "rapid, far-reaching, and unprecedented" changes to life as we know it to combat the global climate crisis, a new report from the Intergovernmental Panel on Climate Change (IPCC) - the United Nations' leading body for climate science - details what the world could look like if the global temperature rises to 1.5^{o}C versus 2^{o}C (2.7^{o}F versus 3.6^{o}F) above pre-industrial levels, and outlines pathways to reducing greenhouse gas emissions in the context of sustainable development and efforts to eradicate poverty.

"Climate change represents an urgent and potentially irreversible threat to human societies and the planet," the report reads. "Human-induced warming has already reached about 1^{o}C (1.8^{o}F) above pre-industrial levels at the time of writing of this Special Report... If the current warming rate continues, the world would reach human-induced global warming of 1.5^{o}C around 2040."

Approved by the IPCC in South Korea on Saturday ahead of COP24 in Poland in December, Global Warming of 1.5^{o}C was produced by 91 authors and reviewers from 40 countries. Its release has elicited calls to action from climate campaigners and policymakers the world over.

"This is a climate emergency. The IPCC 1.5 report starkly illustrates the difference between temperature rises of 1.5^{o}C and 2^{o}C - for many around the world this is a matter of life and death," declared Karin Nansen, chair of Friends of the Earth International (FOEI). "It is crucial to keep temperature rise well below 1.5 degrees ... but the evidence presented by the IPCC shows that there is a narrow and shrinking window in which to do so."

The report was requested when the international community came together in December of 2015 for the Paris agreement, which aims to keep global warming within this century "well below" 2^{o}C, with an ultimate target of 1.5^{o}C. President Donald Trump's predecessor supported the accord, but Trump has

[19] https://www.commondreams.org/news/2018/10/08/un-experts-warn-climate-catastrophe-2040-without-rapid-and-unprecedented-global

vowed to withdraw the United States, even as every other nation on the planet has pledged their support for it. In many cases, however, sworn support hasn't led to effective policy.

"It's a fresh reminder, if one was needed, that current emissions reduction pledges are not enough to meet the long-term goals of the Paris agreement. Indeed, they are not enough for any appropriately ambitious temperature target, given what we know about dangerous climate impacts already unfolding even at lower temperature thresholds," Rachel Cleetus, lead economist and climate policy manager for the Union of Concerned Scientists (UCS), wrote ahead of its release.

"The policy implications of the report are obvious: We need to implement a suite of policies to sharply limit carbon emissions and build climate resilience, and we must do all this is in a way that prioritizes equitable outcomes particularly for the world's poor and marginalized communities," Cleetus added.

"We want a just transition to a clean energy system that benefits people not corporations," Nansen emphasized. "Only with a radical transformation of our energy, food and economic systems, embracing environmental, social, gender and economic justice, can we prevent climate catastrophe and temperature rises exceeding 1.5°C."

Only immediate climate action can save the future

Immediate action to halt the extraction of fossil fuels and greatly reduce the emission of CO_2 and other greenhouse gasses is needed to save the long-term future of human civilization and the biosphere.

At the opening ceremony of United Nations-sponsored climate talks in Katowice, Poland, Sir David Attenborough said "Right now, we are facing a man-made disaster of global scale. Our greatest threat in thousands of years. Climate change. If we don't take action, the collapse of our civilizations and the extinction of much of the natural world is on the horizon. The world's people have spoken. Their message is clear. Time is running out. They want you, the decision-makers, to act now."

Antonio Guterres, UN Secretary-General, said climate change was already "a matter of life and death" for many countries. He added that the world is "nowhere near where it needs to be" on the transition to a low-carbon economy.

Swedish student Greta Thunberg, is a 16-year-old who has launched a climate protest movement in her country. She said, in a short but very clear speech after that of UN leader Antonio Guterres: "Some people say that I should be in school instead. Some people say that I should study to become a climate scientist so that I can 'solve the climate crisis'. But the climate crisis has already been solved. We already have all the facts and solutions."

She added: "Why should I be studying for a future that soon may be no more, when no one is doing anything to save that future? And what is the point of learning facts when the most important facts clearly mean nothing to our society?"

Thunberg continued: "Today we use 100 million barrels of oil every single day. There are no politics to change that. There are no rules to keep that oil in the ground. So we can't save the world by playing by the rules. Because the rules have to be changed."

She concluded by saying that "since our leaders are behaving like children, we will have to take the responsibility they should have taken long ago."

Institutional inertia

Our collective failure to respond adequately to the current crisis is very largely due to institutional inertia. Our financial system is deeply embedded and resistant to change. Our entire industrial infrastructure is based on fossil fuels; but if the future is to be saved, the use of fossil fuels must stop. International relations are still based based on the concept of absolutely sovereign nation states, even though this concept has become a dangerous anachronism in an era of instantaneous global communication and economic interdependence. Within nations, systems of law and education change very slowly, although present dangers demand rapid revolutions in outlook and lifestyle.

The failure of the recent climate conferences to produce strong final documents can be attributed to the fact that the nations attending the conferences felt themselves to be in competition with each other, when in fact they ought to have cooperated in response to a common danger. The heavy hand of the fossil fuel industry also made itself felt at the conferences.

Until the development of coal-driven steam engines in the 19th century humans lived more or less in harmony with their environment. Then, fossil fuels, representing many millions of years of stored sunlight, were extracted and burned in two centuries, driving a frenzy of growth of population and industry that has lasted until the present. But today, the party is over. Coal, oil and gas are nearly exhausted, and what remains of them must be left in the ground to avoid existential threats to humans and the biosphere. Big coal and oil corporations base the value of their stocks on ownership of the remaining resources that are still buried, and they can be counted on to use every trick, fair or unfair, to turn those resources into money.

In general corporations represent a strong force resisting change. By law, the directors of corporations are obliged to put the profits of stockholders above every other consideration. No room whatever is left for an ecological or social conscience. Increasingly, corporations have taken control of our mass media and our political system. They intervene in such a way as to make themselves richer, and thus to increase their control of the system.

Polite conversation and cultural inertia

Each day, the conventions of polite conversation contribute to our sense that everything is as it always was. Politeness requires that we do not talk about issues that might be contrary to another person's beliefs. Thus polite conversation is dominated by trivia, entertainment, sports, the weather, gossip, food, and so on, Worries about the the distant future , the danger of nuclear war, the danger of uncontrollable climate change, or the

danger of widespread famine seldom appear in conversations at the dinner table, over coffee or at the pub. In conversations between polite people, we obtain the false impression that all is well with the world. But in fact, all is not well. We have to act promptly and adequately to save the future.

The situation is exactly the same in the mass media. The programs and articles are dominated by trivia and entertainment. Serious discussions of the sudden crisis which civilization now faces are almost entirely absent, because the focus is on popularity and ratings. As Neil Postman remarked, we are entertaining ourselves to death.

Further growth implies future collapse

We have to face the fact that endless economic growth on a finite planet is a logical impossibility, and that we have reached or passed the the sustainable limits to growth.

In today's world, we are pressing against the absolute limits of the earth's carrying capacity, and further growth carries with it the danger of future collapse. In the long run, neither the growth of industry not that of population is sustainable; and we have now reached or exceeded the sustainable limits.

Our responsibility to future generations and to the biosphere

All of the technology needed for the replacement of fossil fuels by renewable energy is already in place. Although renewable sources currently supply only 19 percent of the world's energy requirements, they are growing rapidly. For example, wind energy is growing at the rate of 30 percent per year. Because of the remarkable properties of exponential growth, this will mean that wind will soon become a major supplier of the world's energy requirements, despite bitter opposition from the fossil fuel industry.

Both wind and solar energy can now compete economically with fossil fuels, and this situation will become even more pronounced if more countries put a tax on carbon emissions, as Finland, the Netherlands, Norway, Costa Rica, the United Kingdom and Ireland already have done. [20]

Much research and thought have also been devoted to the concept of a steady-state economy. The only thing that is lacking is political will. It is up to the people of the world to make their collective will felt. [21]

History has given to our generation an enormous responsibility towards future generations. We must achieve a new kind of economy, a steady-state economy. We must stabilize global population. We must replace fossil fuels by renewable energy. We must abolish nuclear weapons. We must end the institution of war. We must reclaim democracy in our own countries when it has been lost. We must replace nationalism by a just system of international law. We must prevent degradation of the earth's environment. We must act with dedication and fearlessness to save the future of the earth for human civilization and

[20] http://eruditio.worldacademy.org/issue-5/article/urgent-need-renewable-energy
[21] http://steadystate.org/category/herman-daly/

for the plants and animals with which we share the gift of life.

"And yes, we do need hope. Of course, we do. But the one thing we need more than hope is action. Once we start to act, hope is everywhere. So instead of looking for hope, look for action. Then and only then, hope will come today."
Greta Thunberg

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Chapter 3

CLIMATE CHANGE DENIAL

3.1 Donald Trump's climate change denial

In a recent article, climate expert Dr. Andrew Glickson wrote: "The train has left the station and global heating is advancing toward +2 and then toward+4 degrees Celsius, as projected by the IPCC and in the words of Joachim Hans Schellnhuber, Germany's chief climate scientist, signifies the breakdown of civilization. Largely ignored or watered down by much of the mainstream media , betrayed by most political parties, including those who used to regard climate change as "the greatest moral issue of our time", the population continues to be distracted by bread and circuses. Nowadays even some of the Greens appear to consider plastic bags and the tampon tax as greater vote winners than the demise of the biosphere."

Why did Professor Noam Chomsky call the US Republican Party "The most dangerous organization in the history of the world"? In the primary that preceded the 2016 presidential election, every single Republican candidate with a chance of being nominated was a climate change denier. All received amazingly generous checks from giant fossil fuel organizations. When elected, Donald Trump not only pulled the United States out of the Paris Agreement; he also sabotaged the Environmental Protection Agency to such an extent that the carefully collected facts on climate change that the agency had accumulated had to be secretly saved by scientists to prevent their destruction by the Trump administration. Furthermore, Donald Trump not only subsidizes giant coal corporations. He also has sabotages renewable energy initiatives in the United States.

Here are some quotations from an article by Coral Davenport and Mark Landler, May 27, 2019[1]:

President Trump has rolled back environmental regulations, pulled the United States out of the Paris climate accord, brushed aside dire predictions about the effects of climate change, and turned the term "global warming" into a punch line rather than a prognosis.

[1]https://www.nytimes.com/2019/05/27/us/politics/trump-climate-science.html

Now, after two years spent unraveling the policies of his predecessors, Mr. Trump and his political appointees are launching a new assault.

In the next few months, the White House will complete the rollback of the most significant federal effort to curb greenhouse-gas emissions, initiated during the Obama administration. It will expand its efforts to impose Mr. Trump's hard-line views on other nations, building on his retreat from the Paris accord and his recent refusal to sign a communiqué to protect the rapidly melting Arctic region unless it was stripped of any references to climate change.

And, in what could be Mr. Trump's most consequential action yet, his administration will seek to undermine the very science on which climate change policy rests.

Mr. Trump is less an idealogue than an armchair naysayer about climate change, according to people who know him. He came into office viewing agencies like the Environmental Protection Agency as bastions of what he calls the "deep state," and his contempt for their past work on the issue is an animating factor in trying to force them to abandon key aspects of the methodology they use to try to understand the causes and consequences of a dangerously warming planet.

As a result, parts of the federal government will no longer fulfill what scientists say is one of the most urgent jobs of climate science studies: reporting on the future effects of a rapidly warming planet and presenting a picture of what the earth could look like by the end of the century if the global economy continues to emit heat-trapping carbon dioxide pollution from burning fossil fuels...

The administration's prime target has been the National Climate Assessment, produced by an interagency task force roughly every four years since 2000. Government scientists used computer-generated models in their most recent report to project that if fossil fuel emissions continue unchecked, the earth's atmosphere could warm by as much as eight degrees Fahrenheit by the end of the century. That would lead to drastically higher sea levels, more devastating storms and droughts, crop failures, food losses and severe health consequences.

Figure 3.1: **There is so much wrong with Donald Trump that one hardly knows where to start. He is a bully, braggart, narcicist, racist, mysogenist, habitual liar, and tax evader, in addition to being demonstrably ignorant. He has contempt for both domestic and international law, as well as for the US Constitution. In the words of Michael Moore, he is a "part-time clown and full-time sociopath". However, it is Trump's climate change denial, withdrawal from the Paris agreement, and sponsorship of fossil fuels that pose the greatest threats to the future of humans society and the biosphere. The general support of the Republican Party for the fossil fuel industry is the reason why Prof. Noam Chomsky has called the party "the most dangerous organization in history".**

3.2 Jair Bolsonaro, the Trump of the Tropics

The newly elected President of Brazil, Jair Bolsonaro, has praised Pinochet, expressed support for torturers and called for political opponents to be shot, earning him the label of "the most misogynistic, hateful elected official in the democratic world". Bolsonaro speaks nostalgically about the country's 1964-1985 military dictatorship and has promised to fill his government with current and former military leaders. Here, in his own words, are some of his ideas:

On refugees: "The scum of the earth is showing up in Brazil, as if we didn't have enough problems of our own to sort out." (September 2015)

On gay people: "I would be incapable of loving a homosexual son. I'm not going to be a hypocrite: I'd rather my son died in an accident than showed up with some bloke with a moustache." (June 2011)

On democracy and dictatorship: "You'll never change anything in this country through voting. Nothing. Absolutely nothing. Unfortunately, things will only change when a civil war kicks off and we do the work the [military] regime didn't. Killing some 30,000... Killing them! If a couple of innocents die, that's OK." (May 1999)

On human rights: "I'm in favour of torture." (May 1999)

On women: "I said I wouldn't rape you because you don't deserve it." (December 2014, to politician Maria do Rosário, repeating a comment first made to her in 2003).

Indigenous rights activists fear Bolsonaro's avowed plan to wring riches from the Amazon - whether from expanding agriculture into indigenous lands, building roads and other infrastructure projects, or allowing mining on public lands - will unleash a tide of violence and environmental devastation.

"All indigenous communities are afraid right now," says Felipe Milanez, professor of humanities at the Universidade Federal de Bahia. "There is a risk of brutal, violent attack." Milanez fears that indigenous efforts to patrol and protect their own lands from outsiders, such as the Forest Guardians recently covered in National Geographic magazine, will be banned and persecuted.

"His economic project is to destroy the Amazon, to transform the Amazon into commodities for export," Milanez says.

Human rights activists are concerned that a surge in violent land conflicts will accompany an increase in environmentally destructive development in the Amazon. "There is no doubt that devastation will spread in the region," says Diogo Cabral, an attorney with the Sociedade Maranhense de Direitos Humanos. "At the same time, he aims to extinguish policies that protect human rights defenders in Brazil. Under Bolsonaro, human life will have no value."

Figure 3.2: **Jair Bolsonaro visiting Donald Trump in Washington. Like Trump, he is an utterly despicable person, but (again like Trump) his worst crime is against the future of human civilization and the biosphere. Under Bolsonaro, the vitally important Amazon rainforests are being destroyed, a terrible blow to our efforts to avoid catastrophic ciliate change.**

Figure 3.3: **The indigenous peoples of the Amazon are the guardians of the lungs of Planet Earth. Within hours of taking office on 1 January, 2019, the Trump of the Tropics, aka the new President of Brazil, Jair Bolsonaro, launched an all-out assault against the Amazon rainforest and its indigenous communities, potentially paving the way for large scale deforestation by agricultural, mining and oil companies.**

The indigenous peoples' website Mongabay [2] states that "The potentially resulting wholesale deforestation could be a disaster to indigenous peoples, biodiversity, and even the regional and global climate."

It adds: "Bolsonaro's proposed Amazon policies, if carried out, could ultimately help dash the world's hopes of achieving the global climate goals agreed to in Paris, a failure that could lead to climate chaos."

Leading Brazilian researchers, from the National Institute of Space Research (INPE), have calculated that Bolsonaro's policies could triple deforestation in the Amazon from present levels of 6,900 square kilometers (2,664 square miles) annually, to 25,600 square kilometers (9,884 square miles) per year by 2020.

3.3 The Evangelicals believe that there is no need to act

Here is an excerpt frp, an article by Bernard Daley Zaleha and Andrew Szasz entitled *Why conservative Christians don't believe in climate change*[3]:

American Christians have become increasingly polarized on issues of climate change and environmental regulation. In recent years, mainline Protestant denominations and the Roman Catholic Church have made explicit declarations of support for global climate action. Prominent Southern Baptists and other evangelical Protestants, on the other hand, have issued statements that are strikingly similar to the talking points of secular climate skeptics, and have attempted to stamp out "green" efforts within their own ranks. An analysis of resolutions and campaigns by evangelicals over the past 40 years shows that anti-environmentalism within conservative Christianity stems from fears that "stewardship" of God's creation is drifting toward neo-pagan nature worship, and from apocalyptic beliefs about "end times" that make it pointless to worry about global warming. As the climate crisis deepens, the moral authority of Christian leaders and organizations may play a decisive role in swaying public policy toward (or away from) action to mitigate global warming.

The highly dangerous beliefs of the Evangelicals are in strong contrast to the courageous and enlightened leadership of Pope Francis, who urges us to act resolutely to prevent catastrophic climate change.

[2]https://news.mongabay.com/2019/01/bolsonaro-hands-over-indigenous-land-demarcation-to-agriculture-ministry/?fbclid=IwAR3UG-jneDheuddVEWVcCrcWKk4bnnsdE1uIBMLlnLtS6zGqMmGSPxtgEzM

[3]Bulletin of the Atomic Scientists 2015, Vol. 71(5) 19-30

3.4 Banks give fossil fuel giants $1.9 trillion since Paris

Banking on Climate Change 2019 - Fossil Fuel Report Card / : Alison Kirsch et al Rainforest Action Network (RAN) et al.. For the first time, this report adds up lending and underwriting from 33 global banks to the fossil fuel industry as a whole. The findings are stark: these Canadian, Chinese, European, Japanese, and U.S. banks have financed fossil fuels with $1.9 trillion since the Paris Agreement was adopted (2016-2018), with financing on the rise each year. This report finds that fossil fuel financing is dominated by the big U.S. banks, with JPMorgan Chase as the world's top funder of fossil fuels by a wide margin. In other regions, the top bankers of fossil fuels are Royal Bank of Canada in Canada, Barclays in Europe, MUFG in Japan, and Bank of China in China. Here are some quotations from the report:

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) released a sobering report on the devastating impacts our world will face with 1.5^o Celsius of warming - let alone 2^{o}C - while setting out the emissions trajectory the nations of the world need to take if we are to have any shot at keeping to that 1.5^{o}C limit. This 10th edition of the annual fossil fuel finance report card, greatly expanded in scope, reveals the paths banks have taken in the past three years since the Paris Agreement was adopted, and finds that overall bank financing continues to be aligned with climate disaster.

For the first time, this report adds up lending and underwriting from 33 global banks to the fossil fuel industry as a whole. The findings are stark: these Canadian, Chinese, European, Japanese, and U.S. banks have financed fossil fuels with $1.9 trillion since the Paris Agreement was adopted (2016-2018), with financing on the rise each year. This report finds that fossil fuel financing is dominated by the big U.S. banks, with JPMorgan Chase as the world's top funder of fossil fuels by a wide margin. In other regions, the top bankers of fossil fuels are Royal Bank of Canada in Canada, Barclays in Europe, MUFG in Japan, and Bank of China in China.

This report also puts increased scrutiny on the banks' support for 100 top companies that are expanding fossil fuels, given that there is no room for new fossil fuels in the world's carbon budget. And yet banks supported these companies with $600 billion in the last three years. JPMorgan Chase is again on top, by an even wider margin, and North American banks emerge as the biggest bankers of expansion as well.

This report also grades banks' overall future-facing policies regarding fossil fuels, assessing them on restrictions on financing for fossil fuel expansion and commitments to phase out fossil fuel financing on a 1.5^{o}C-aligned trajectory. While some banks have taken important steps, overall major global banks have simply failed to set trajectories adequate for dealing with the climate crisis.


UnionBank
MUFG UnionBank:
STOP BANKROLLING
CLIMATE CHANGE
気候変動に融資しないで
COAL
KILLS
WATER
IS SACRED
NO PIPELINES!
KEEP IT IN THE
GROUND
PROTECT
OUR
CLIMATE
WATER
AND
HEALTH
NO TAR SANDS
#NoDAPL
WATER
LIFE
MNI WICHONI


NO DAPL
JP Morgan Chase
DON'T FUND
TRANS MOUNTAIN
RAINFOREST
ACTION NETWORK
#DEFUND TARSANDS

As in past editions, this fossil fuel finance report card also assesses bank policy and practice around financing in certain key fossil fuel subsectors, with league tables and policy grades on:

- **Tar sands oil: RBC, TD, and JPMorgan Chase are the biggest bankers of 30 top tar sands producers, plus four key tar sands pipeline companies. In particular, these banks and their peers support companies working to expand tar sands infrastructure, such as Enbridge and Teck Resources.**
- **Arctic oil and gas: JPMorgan Chase is the world's biggest banker of Arctic oil and gas by far, followed by Deutsche Bank and SMBC Group. Worryingly, financing for this subsector increased from 2017 to 2018.**
- **Ultra-deepwater oil and gas: JPMorgan Chase, Citi, and Bank of America are the top bankers here. Meanwhile, none of the 33 banks have policies to proactively restrict financing for ultra-deepwater extraction.**
- **Fracked oil and gas: For the first time, the report card looks at bank support for top fracked oil and gas producers and transporters - and finds financing is on the rise over the past three years. Wells Fargo and JPMorgan Chase are the biggest bankers of fracking overall - and, in particular, they support key companies active in the Permian Basin, the epicenter of the climate-threatening global surge of oil and gas production.**
- **Liquefied natural gas (LNG): Banks have financed top companies building LNG import and export terminals around the world with $46 billion since the Paris Agreement, led by JPMorgan Chase, Société Générale, and SMBC Group. Banks have an opportunity to avoid further damage by not financing Anadarko's Mozambique LNG project, in particular.**
- **Coal mining: Coal mining finance is dominated by the four major Chinese banks, led by China Construction Bank and Bank of China. Though many European and U.S. banks have policies in place restricting financing for coal mining, total financing has only fallen by three to five percentage points each year.**
- **Coal power: Coal power financing is also led by the Chinese banks - Bank of China and ICBC in particular - with Citi and MUFG as the top non-Chinese bankers of coal power. Policy grades for this subsector show some positive examples of European banks restricting financing for coal power companies.**

The human rights chapter of this report shows that as fossil fuel companies are increasingly held accountable for their contributions to climate change, finance for these companies also poses a growing liability risk for banks. The

Figure 3.4: **Drilling for oil in the Arctic.**

fossil fuel industry has been repeatedly linked to human rights abuses, including violations of the rights of Indigenous peoples and at-risk communities, and continues to face an ever-growing onslaught of lawsuits, resistance, delays, and political uncertainty.

The IPCC's 2018 report on the impacts of a 1.5^{o}C increase in global temperature showed clearly the direction the nations of the world need to take, and the emissions trajectory we need to get there. Banks must align with that trajectory by ending financing for expansion, as well as for these particular spotlight fossil fuels - while committing overall to phase out all financing for fossil fuels on a Paris Agreement-compliant timeline.

Figure 3.5: **Indigenous protests against Arctic drilling.**


CHASE:
STOP
PROFITING OFF
DIRTY ENERGY
& RIGHTS ABUSES
CHASE
JP MorganChase
DON'T FUND
TRANS MOUNTAIN


NO DAPL
JP MorganChase
DON'T FUND
TRANS MOUNTAIN
RAINFOREST
ACTION NETWORK
#DEFUND TAR SANDS

Figure 3.6: **A coal-fired power plant.**

3.5 Fossil fuel industry's disinformation campaign

The Wikipedia article on climate change denial describes it with the following words: "Although scientific opinion on climate change is that human activity is extremely likely to be the primary driver of climate change, the politics of global warming have been affected by climate change denial, hindering efforts to prevent climate change and adapt to the warming climate. Those promoting denial commonly use rhetorical tactics to give the appearance of a scientific controversy where there is none."

It is not surprising that the fossil fuel industry supports, on a vast scale, politicians and mass media that deny the reality of climate change. The amounts of money at stake are vast. If catastrophic climate change is to be avoided, coal, oil and natural gas "assets" worth trillions of dollars must be left in the ground. Giant fossil fuel corporations are desperately attempting to turn these "assets' into cash.

According to a recent article published in "The Daily Kos"[4], companies like Shell and Exxon, knew, as early as the 1970s, how their combustible products were contributing to irreversible warming of the planet, became public knowledge over the last few years.

A series of painstakingly researched articles[5] published in 2015 by the Pulitzer-prize

[4]ww.dailykos.com/stories/2018/9/23/1797888/-The-Oil-Companies-not-only-knew-fossil-fuels-caused-climate-change-they-knew-how-bad-it-would-get?detail=emaildkre

[5]https://insideclimatenews.org/news/15092015/Exxons-own-research-confirmed-fossil-fuels-role-in-global-warming

winning Inside Climate News revealed an industry totally aware and informed for decades about the inevitable warming certain to occur as more and more carbon dioxide from the burning of fossil fuels was released into the atmosphere.

The article states that "In fact, the oil industry, and Exxon in particular, had the best climate models available, superior to those relied on by scientific community.[6] And armed with the foreknowledge developed through those models, Exxon and the other oil companies planned and executed an elaborate, cynical long term strategy: to invest hundreds of millions of dollars in a comprehensive propaganda effort designed to raise doubts about the existence and cause of climate change, a phenomenon they well knew was irrefutable, based on their own research. By 2016 the industry's lobbying to discredit the science of climate change had surpassed two billion dollars.

"Meanwhile, as newly discovered documents reported in The Guardian[7] attest, the same companies were preparing projections of what type of world they would be leaving for the rest of humanity. In the 1980s, oil companies like Exxon and Shell carried out internal assessments of the carbon dioxide released by fossil fuels, and forecast the planetary consequences of these emissions. In 1982, for example, Exxon predicted that by about 2060, CO_2 levels would reach around 560 parts per million - double the preindustrial level - and that this would push the planet's average temperatures up by about 2^oC over then-current levels (and even more compared to pre-industrial levels)."[8]

The Fossil Free MIT report, 2014

Here are some excerpts from a report entitled **"The Fossil Fuel Industry's Role in Hindering Climate Change Action: Lobbying and Disinformation Against Science and Scientists"**[9]:

In response to the unprecedented urgency of global climate change, Fossil Free MIT's petition, signed by more than 2,400 MIT members, is calling on MIT to divest its $11 billion endowment from the 200 fossil fuel companies with the world's largest publicly traded carbon reserves.

[6]https://insideclimatenews.org/news/18092015/exxon-confirmed-global-warming-consensus-in-1982-with-in-house-climate-models

[7]https://www.theguardian.com/environment/climate-consensus-97-per-cent/2018/sep/19/shell-and-exxons-secret-1980s-climate-change-warnings

[8]See also https://truthout.org/articles/self-immolation-as-the-world-burns-an-earth-day-report/
https://countercurrents.org/2018/04/29/the-methane-time-bomb-and-the-future-of-the-biosphere/
https://countercurrents.org/2018/08/07/hothouse-earth-evidence-for-ademise-of-the-planetary-life-support-system/
https://www.independent.co.uk/environment/global-warming-temperature-rise-climate-change-end-century-science-a8095591.html
http://www.lifeworth.com/deepadaptation.pdf
https://www.independent.co.uk/news/business/news/bp-shell-oil-global-warming-5-degree-paris-climate-agreement-fossil-fuels-temperature-rise-a8022511.html

[9]https://www.fossilfreemit.org/wp-content/uploads/2014/08/FossilFreeMIT-Lobbying-Disinformation.pdf

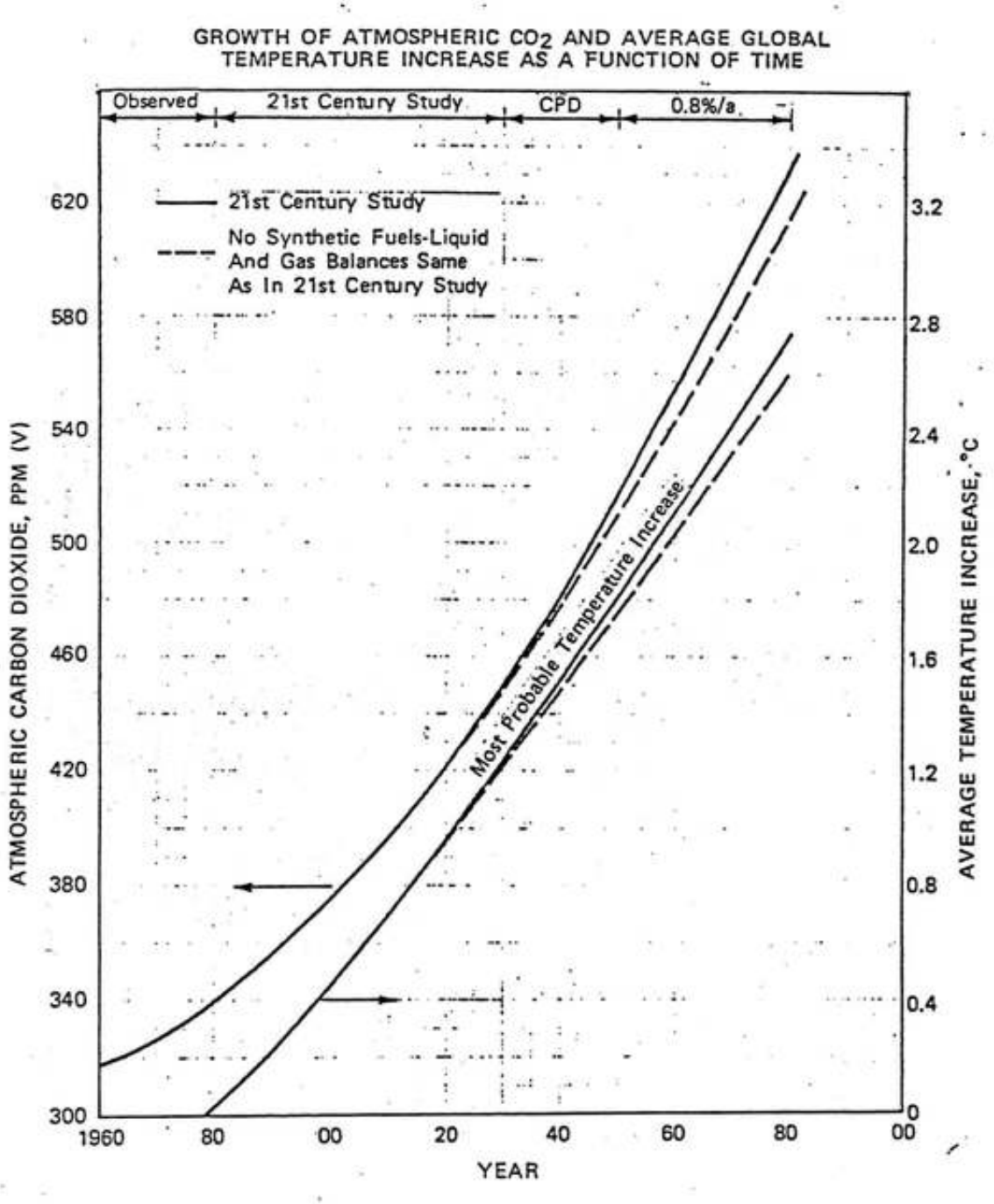

Figure 3.7: **Exxon's 1982 internal projections of the future increase in carbon dioxide levels shows CO_2 percentages increasing to 600 ppm and temperature increases of up to 3°C.**

Fossil Free MIT believes that divestment from the fossil fuel industry presents MIT with a unique opportunity to lead the global effort to combat climate change. We wholeheartedly support our Institute's cutting-edge climate science and renewable energy technology research, as well as MIT's campus sustainability initiatives, and we propose divestment as a highly complementary strategy that will bring MIT's investments in line with the goals of its research and sustainability activities. There are three central reasons why we urge MIT to divest from the fossil fuel industry:

- **The fossil fuel industry's business practice is fundamentally inconsistent with the science of climate change mitigation. A 66% chance of limiting global warming to less than 2^{o}C above pre-industrial temperatures demands that no more than 35% of proven fossil fuel reserves can be burned prior to 2100. Yet in 2012, the fossil fuel industry spent $674 billion developing new reserves.**
- **The fossil fuel industry spends hundreds of millions of dollars lobbying and donating in Washington, D.C. against legislation for climate change action.**
- **Many fossil fuel companies are responsible for funding or orchestrating targeted anti-science disinformation campaigns that confuse the public, sabotage science, and slander scientists.**

Disinformation from fossil fuel and tobacco industries

Here are some excerpts from a February 19 2019 article by Mat Hope entitled **"Revealed: How the Tobacco and Fossil Fuel Industries Fund Disinformation Campaigns Around the World"**[10]:

Fossil fuel companies have a long history of adopting public relations strategies straight from the tobacco industry's playbook. But a new analysis shows the two industries' relationship goes much deeper - right down to funding the same organizations to do their dirty work.

MIT Associate Professor David Hsu analyzed organizations in DeSmog's disinformation database and the Guardian's tobacco database and found 35 thinktanks based in the US, UK, Australia, and New Zealand that promote both the tobacco and fossil fuel industries' interests.

Of these organizations, DeSmog can reveal that 32 have taken direct donations from the tobacco industry, 29 have taken donations from the fossil fuel industry, and 28 have received money from both. Two key networks, based

[10] https://www.desmogblog.com/2019/02/19/how-tobacco-and-fossil-fuel-companies-fund-disinformation-campaigns-around-world

Figure 3.8: **Smoke destroys human health, regardless of whether it is from cigarettes or coal-fired power plants. Fossil fuel corporations and tobacco companies have exhibited an astonishing degree of cynicism and lack of social responsibility.**

around the Koch brothers and Atlas Network, are involved in coordinating or funding many of the thinktanks.

3.6 The UK declares a climate emergency

Introducing the motion in the House of Commons, Labour leader Jeremy Corbyn said: **"We have no time to waste. We are living in a climate crisis that will spiral dangerously out of control unless we take rapid and dramatic action now. This is no longer about a distant future. We're talking about nothing less than the irreversible destruction of the environment within our lifetimes of members of this house."**

Here are some excerpts from an article by Amy Goodman and Nermeen Shaikh of Democracy now published in Truthout on May 2, 2019.[11]:

On Wednesday, the House of Commons became the first parliament in the world to declare a climate emergency. The resolution came on the heels of the recent Extinction Rebellion mass uprising that shut down Central London last month in a series of direct actions. Activists closed bridges, occupied public landmarks and even superglued themselves to buildings, sidewalks and trains

[11]https://truthout.org/video/george-monbiot-on-the-uk-climate-emergency/

to demand urgent action to combat climate change. Police arrested more than 1,000 protesters. Labour Party Leader Jeremy Corbyn told Parliament, "We are witnessing an unprecedented upsurge of climate activism, with groups like Extinction Rebellion forcing the politicians in this building to listen. For all the dismissive and defensive column inches the processes have provoked, they are a massive and, I believe, very necessary wake-up call. Today we have the opportunity to say, 'We hear you.'" We speak with George Monbiot, British journalist, author and columnist with The Guardian. His recent piece for The Guardian is headlined "Only rebellion will prevent an ecological apocalypse." Monbiot says capitalism "is like a gun pointed at the heart of the planet. It will essentially, necessarily destroy our life-support systems. Among those characteristics is the drive for perpetual economic growth on a finite planet."

3.7 The 2018 IPCC report

Excerpts from an article summarizing the report

Here are excerpts from an article entitled **UN Experts Warn of 'Climate Catastrophe' by 2040** by Jesica Corbett. The article was published in Common Dreams on Monday, October 8, 2018.[12]:

[12]https://www.commondreams.org/news/2018/10/08/un-experts-warn-climate-catastrophe-2040-without-rapid-and-unprecedented-global

"The climate crisis is here and already impacting the most vulnerable," notes 350.org's program director. "Staying under 1.5^{o}C is now a matter of political will."

Underscoring the need for "rapid, far-reaching, and unprecedented" changes to life as we know it to combat the global climate crisis, a new report from the Intergovernmental Panel on Climate Change (IPCC) - the United Nations' leading body for climate science - details what the world could look like if the global temperature rises to 1.5^{o}C versus 2^{o}C (2.7^{o}F versus 3.6^{o}F) above pre-industrial levels, and outlines pathways to reducing greenhouse gas emissions in the context of sustainable development and efforts to eradicate poverty.

"Climate change represents an urgent and potentially irreversible threat to human societies and the planet," the report reads. "Human-induced warming has already reached about 1^{o}C (1.8^{o}F) above pre-industrial levels at the time of writing of this Special Report... If the current warming rate continues, the world would reach human-induced global warming of 1.5^{o}C around 2040."

Approved by the IPCC in South Korea on Saturday ahead of COP24 in Poland in December, Global Warming of 1.5^{o}C was produced by 91 authors and reviewers from 40 countries. Its release has elicited calls to action from climate campaigners and policymakers the world over.

"This is a climate emergency. The IPCC 1.5 report starkly illustrates the difference between temperature rises of 1.5^{o}C and 2^{o}C - for many around the world this is a matter of life and death," declared Karin Nansen, chair of Friends of the Earth International (FOEI). "It is crucial to keep temperature rise well below 1.5 degrees ... but the evidence presented by the IPCC shows that there is a narrow and shrinking window in which to do so."

The report was requested when the international community came together in December of 2015 for the Paris agreement, which aims to keep global warming within this century "well below" 2^{o}C, with an ultimate target of 1.5^{o}C. President Donald Trump's predecessor supported the accord, but Trump has vowed to withdraw the United States, even as every other nation on the planet has pledged their support for it. In many cases, however, sworn support hasn't led to effective policy.

"It's a fresh reminder, if one was needed, that current emissions reduction pledges are not enough to meet the long-term goals of the Paris agreement. Indeed, they are not enough for any appropriately ambitious temperature target, given what we know about dangerous climate impacts already unfolding even at lower temperature thresholds," Rachel Cleetus, lead economist and climate policy manager for the Union of Concerned Scientists (UCS), wrote ahead of its release.

"The policy implications of the report are obvious: We need to implement a suite of policies to sharply limit carbon emissions and build climate resilience, and we must do all this is in a way that prioritizes equitable outcomes particularly for the world's poor and marginalized communities," Cleetus added.

"We want a just transition to a clean energy system that benefits people not corporations," Nansen emphasized. "Only with a radical transformation of our energy, food and economic systems, embracing environmental, social, gender and economic justice, can we prevent climate catastrophe and temperature rises exceeding 1.5°C."

Today we are faced with multiple interrelated crises, for example the threat of catastrophic climate change or equally catastrophic thermonuclear war, and the threat of widespread famine. These threats to human existence and to the biosphere demand a prompt and rational response; but because of institutional and cultural inertia, we are failing to take the steps that are necessary to avoid disaster.

3.8 Greta Thunberg

Only immediate climate action can save the future

Immediate action to halt the extraction of fossil fuels and greatly reduce the emission of CO_2 and other greenhouse gasses is needed to save the long-term future of human civilization and the biosphere.

At the opening ceremony of United Nations-sponsored climate talks in Katowice, Poland, Sir David Attenborough said "Right now, we are facing a man-made disaster of global scale. Our greatest threat in thousands of years. Climate change. If we don't take action, the collapse of our civilizations and the extinction of much of the natural world is on the horizon. The world's people have spoken. Their message is clear. Time is running out. They want you, the decision-makers, to act now."

Antonio Guterres, UN Secretary-General, said climate change was already "a matter of life and death" for many countries. He added that the world is "nowhere near where it needs to be" on the transition to a low-carbon economy.

Swedish student Greta Thunberg, is a 16-year-old who has launched a climate protest movement in her country. She said, in a short but very clear speech after that of UN leader Antonio Guterres: "Some people say that I should be in school instead. Some people say that I should study to become a climate scientist so that I can 'solve the climate crisis'. But the climate crisis has already been solved. We already have all the facts and solutions."

She added: "Why should I be studying for a future that soon may be no more, when no one is doing anything to save that future? And what is the point of learning facts when the most important facts clearly mean nothing to our society?"

Thunberg continued: "Today we use 100 million barrels of oil every single day. There are no politics to change that. There are no rules to keep that oil in the ground. So we can't save the world by playing by the rules. Because the rules have to be changed."

She concluded by saying that "since our leaders are behaving like children, we will have to take the responsibility they should have taken long ago."

Appearing among billionaires, corporate CEO's and heads of state at the Davos Economic Forum in Switzerland, like a new Joan of Arc, 16-year-old Swedish climate activist

Greta Thunberg called on decision-makers to fulfil their responsibilities towards future generations. Here are some excerpts from her speech:

Greta's speech at Davos

Our house is on fire. I am here to say, our house is on fire. According to the IPCC, we are less than 12 years away from not being able to undo our mistakes. In that time, unprecedented changes in all aspects of society need to have taken place, including a reduction of our CO_2 emissions by at least 50%...

Here in Davos - just like everywhere else - everyone is talking about money. It seems money and growth are our only main concerns.

And since the climate crisis has never once been treated as a crisis, people are simply not aware of the full consequences on our everyday life. People are not aware that there is such a thing as a carbon budget, and just how incredibly small that remaining carbon budget is. That needs to change today.

No other current challenge can match the importance of establishing a wide, public awareness and understanding of our rapidly disappearing carbon budget, that should and must become our new global currency and the very heart of our future and present economics.

We are at a time in history where everyone with any insight of the climate crisis that threatens our civilization - and the entire biosphere - must speak out in clear language, no matter how uncomfortable and unprofitable that may be.

We must change almost everything in our current societies. The bigger your carbon footprint, the bigger your moral duty. The bigger your platform, the bigger your responsibility.

Figure 3.9: **Greta Thunberg on the cover of Time Magazine, The Intergovernmental Panel on Climate Change, in their October 2018 report, used strong enough language to wake up at least part of the public: the children whose future is at stake. Here is an excerpt from a speech which 16-year-old Swedish climate activist Greta Thunberg made at the Davos Economic Forum in January, 2019: "Our house is on fire. I am here to say, our house is on fire. According to the IPCC, we are less than 12 years away from not being able to undo our mistakes. In that time, unprecedented changes in all aspects of society need to have taken place, including a reduction of our CO2 emissions by at least 50%..."**

3.9 Worldwide school strike, 15 March, 2019

Inspired by Greta Thunberg, over 1.4 million young students across all continents took to the streets on Friday March 15th for the first ever global climate strike. Messages in more than 40 languages were loud and clear: world leaders must act now to address the climate crisis and save our future. The school strike was the largest climate action in history. Nevertheless it went almost unmentioned in the media,

Here are some of the statements by the students explaining why they took part in the strikes:

In India, no one talks about climate change. You don't see it on the news or in the papers or hear about it from government. We want global leaders to declare a climate emergency. If we don't act today, then we will have no tomorrow. - Vidit Baya, 17, Udaipur, India.

We face heartbreaking loss due to increasingly extreme weather events. We urge the Taiwanese government to implement mitigation measures and face up to the vulnerability of indigenous people, halt construction projects in the indigenous traditional realm, and recognize the legal status of Plains Indigenous People, in order to implement environmental protection as a bottom-up approach - Kaisanan Ahuan, Puli City, Taiwan.

We have reached a point in history when we have the technical capacities to solve poverty, malnutrition, inequality and of course global warming. The deciding factors for whether we take advantage of our potential will be our activism, our international unity and our ability to develop the art of making the impossible possible. Whether we succeed or not depends on our political will - Eyal Weintraub, 18, and Bruno Rodriguez, 18, Argentina.

The damage done by multinationals is enormous: the lack of transparency, dubious contracts, the weakening of the soil, the destruction of flora and fauna, the lack of respect for mining codes, the contamination of groundwater. In Mali, the state exercises insufficient control over the practices of the multinationals, and it is us, the citizens, who suffer the consequences. The climate alarm has sounded, and the time has come for us all to realize that there is still time to act locally, in our homes, our villages, our cities - Mone Fousseny, 22, Mali.

3.10 Forms of renewable energy

Solar energy

Before the start of the industrial era, human society relied exclusively on renewable energy sources - but can we do so again, with our greatly increased population and greatly increased demands? Will we ultimately be forced to reduce the global population or our per capita use of energy, or both? Let us now try to examine these questions.

Biomass, wind energy, hydropower and wave power derive their energy indirectly from the sun, but in addition, various methods are available for utilizing the power of sunlight directly. These include photovoltaic panels, solar designs in architecture, solar systems for heating water and cooking, concentrating photovoltaic systems, and solar thermal power plants.

Photovoltaic cells and concentrating photovoltaic systems

Solar power was the fastest-growing source of new energy in 2016, surpassing the net growth of all other energy sources including coal, according to a new report from the International Energy Agency (IEA).

The IEA report found new solar capacity increased by 50 percent in 2016, and IEA executive director Fatih Birol hailed solar's rapid growth. "What we are witnessing is the birth of a new era in solar photovoltaics [PV]. We expect that solar PV capacity growth will be higher than any other renewable technology up to 2022."[13]

The report also shows renewables as a whole accounted for two-thirds of all new energy capacity in 2016. "We see renewables growing by about 1,000 GW (gigawatts) by 2022, which equals about half of the current global capacity in coal power, which took 80 years to build," Birol said in a statement accompanying the report.[14]

Solar photovoltaic cells[15] are thin coated wafers of a semiconducting material (usually silicon). The coatings on the two sides are respectively charge donors and charge acceptors. Cells of this type are capable of trapping solar energy and converting it into direct-current electricity. The electricity generated in this way can be used directly (as it is, for example, in pocket calculators) or it can be fed into a general power grid. Alternatively it can be used to split water into hydrogen and oxygen. The gases can then be compressed and stored, or exported for later use in fuel cells. In the future, we may see solar photovoltaic arrays in sun-rich desert areas producing hydrogen as an export product. As their petroleum reserves become exhausted, the countries of the Middle East and Africa may be able to shift to this new technology and still remain energy exporters.

[13] https://www.theguardian.com/environment/2017/oct/04/solar-power-renewables-international-energy-agency

[14] https://www.iea.org/newsroom/news/2017/october/solar-pv-grew-faster-than-any-other-fuel-in-2016-opening-a-new-era-for-solar-pow.html

[15] https://www.iea.org/renewables/

It is interesting to notice that the primary process of photosynthesis in plants is closely similar to the mechanism by which solar cells separate charges and prevent the back-reaction. We can see why a back-reaction must be prevented if we consider the excitation of a single atom. An absorbed photon lifts an electron from a filled atomic orbital to an empty one, leaving a positively-charged hole in the orbital from which the electron came. However, a back-reaction occurs almost immediately: The excited electron falls back into the orbital from which it came, and the absorbed energy is re-emitted. One can say that the electron and hole have recombined.

In higher plants, the back reaction is prevented because the photon is absorbed in a membrane which has a sandwich-like structure. Dye molecules (usually chlorophyll molecules) are sandwiched between a layer of charge donor molecules on one side of the membrane, and a layer of charge acceptor molecule on the other side. The electron quickly migrates to the acceptors, which are molecules with low-lying unfilled orbitals. Meanwhile the hole has quickly moved to the opposite side of the membrane. where it combines with an electron from a donor molecule. A donor molecule is a molecule whose highest filled orbital is high in energy. In this process, the back.reaction is prevented. The electron and hole are on opposite sides of the membrane, and they can only recombine after they have driven the metabolism of the plant.

In a photovoltaic solar cell, the mechanism by which the back-reaction is prevented is exactly similar. It too has a sandwich-like structure, with charge donors on one side, charge-acceptors on the other, and photon absorbers in the middle. Here too, the electron and hole quickly migrate to opposite sides. They can only recombine by traveling through the external circuit, which is analogous to a plant's metabolism, and performing useful work.

The cost of manufacturing photovoltaics continues to fall rapidly. In 2017, a homeowner paid approximately $3,360 per kilowatt to have rooftop solar panels installed Usually photovoltaic panels are warranted for a life of 20 years, but they are commonly still operational after 30 years or more. Using the fact that there are 8760 hours in a year, and thus 175200 hours in 20 years, we can calculate that the cost of electricity to a solar-using homeowner today is about 1.92 cents per kilowatt hour. This can be compared with electricity generated from coal, which in 2011 cost 3.23 cents per kilowatt hour, while electricity generated from natural gas cost 4.51 cents per kilowatt hour. We must also remember that photovoltaics are falling rapidly in price, and that the fossil fuel costs do not include externalities, such as their contribution to climate change.

Concentrating photovoltaic systems are able to lower costs still further by combining silicon solar cells with reflectors that concentrate the sun's rays. The most inexpensive type of concentrating reflector consists of a flat piece of aluminum-covered plastic material bent into a curved shape along one of its dimensions, forming a trough-shaped surface. (Something like this shape results when we hold a piece of paper at the top and bottom with our two hands, allowing the center to sag.) The axis of the reflector can be oriented so that it points towards the North Star. A photovoltaic array placed along the focal line will then receive concentrated sunlight throughout the day.

Photovoltaic efficiency is defined as the ratio of the electrical power produced by a cell

to the solar power striking its surface. For commercially available cells today, this ratio is between 9% and 14%. If we assume 5 hours of bright sunlight per day, this means that a photo cell in a desert area near to the equator (where 1 kW/m^2 of peak solar power reaches the earth's surface) can produce electrical energy at the average rate of 20-30 W$_e$/m^2, the average being taken over an entire day and night. The potential power per unit area for photovoltaic systems is far greater than for biomass. However, the mix of renewable energy sources most suitable for a particular country depends on many factors. We will see below that biomass is a promising future source of energy for Sweden, because of Sweden's low population density and high rainfall. By contrast, despite the high initial investment required, photovoltaics are undoubtedly a more promising future energy source for southerly countries with clear skies.

In comparing photovoltaics with biomass, we should be aware of the difference between electrical energy and energy contained in a the chemical bonds of a primary fuel such as wood or rapeseed oil. If Sweden (for example) were to supply all its energy needs from biomass, part of the biomass would have to be burned to generate electricity. The efficiency of energy conversion in electricity generation from fuel is 20%-35%. Of course, in dual use power plants, part of the left-over heat from electrical power generation can be used to heat homes or greenhouses. However, hydropower, wind power and photovoltaics have an advantage in generating electrical power, since they do so directly and without loss, whereas generation of electricity from biomass involves a loss from the inefficiency of the conversion from fuel energy to electrical energy. Thus a rational renewable energy program for Sweden should involve a mixture of biomass for heating and direct fuel use, with hydropower and wind power for generation of electricity. Perhaps photovoltaics will also play a role in Sweden's future electricity generation, despite the country's northerly location and frequently cloudy skies.

The global market for photovoltaics is expanding at the rate of 30% per year. This development is driven by rising energy prices, subsidies to photovoltaics by governments, and the realization of the risks associated with global warming and consequent international commitments to reduce carbon emissions. The rapidly expanding markets have resulted in lowered photovoltaic production costs, and hence further expansion, still lower costs, etc. - a virtuous feedback loop.

Solar thermal power plants

Solar Parabolic Troughs can be used to heat a fluid, typically oil, in a pipe running along the focal axis. The heated fluid can then be used to generate electrical power. The liquid that is heated in this way need not be oil. In a solar thermal power plant in California, reflectors move in a manner that follows the sun's position and they concentrate solar energy onto a tower, where molten salt is heated to a temperature of 1050 degrees F (566 ^{o}C). The molten salt stores the heat, so that electricity can be generated even when the sun is not shining. The California plant generates 10 MW$_e$.

Figure 3.10: **A rooftop array of photovoltaic cells.**

Figure 3.11: **A solar thermal power plant. Arrays of heliostatic reflectors concentrate the sun's rays onto molten salt in the tower. The plant produces electricity at night because the salt remains hot..**

Figure 3.12: **A solar cooker.**

Figure 3.13: **A rooftop solar thermal array for domestic water heating.**

Solar designs in architecture

At present, the average global rate of use of primary energy is roughly 2 kW_t per person. In North America, the rate is 12 kW_t per capita, while in Europe, the figure is 6 kW_t. In Bangladesh, it is only 0.2 kW_t. This wide variation implies that considerable energy savings are possible, through changes in lifestyle, and through energy efficiency.

Important energy savings can be achieved through solar design in architecture. For example, insulation can be improved in walls, and insulating shutters can be closed at night.

In double envelope construction, a weatherproof shell surrounds the inner house. Between the outer shell and the house, sun-heated air circulates. A less extreme example of this principle is the construction of south-facing conservatories. The sun-heated air in the conservatories acts as a thermal buffer, and reduces heat loss from the house.

Solar design aims at making houses cool in the summer and warm in the winter. Awnings can be spread out in the summer to shade windows, and rolled together in the winter to allow sunshine to enter the house. Alternatively, deciduous trees can be planted in front of south-facing windows. During the summer, the leaves of the trees shade the windows, while in the winter, the leaves fall, allowing the sun to enter.

During daylight hours, houses can be illuminated by fiber optic light pipes, connected to a parabolic collector on the roof. The roof can also contain arrays of solar photovoltaic cells and solar water heaters.

Houses can be heated in the winter by heat pumps connected to a deeply buried network of pipes. Heat pumps function in much the same way as refrigerators or air conditioners. When they are used to warm houses in the winter, a volatile liquid such as ammonia is evaporated underground, where the temperature is relatively constant, not changing much between summer and winter. In the evaporation process, heat is absorbed from the ground. The gas is then compressed and re-liquefied within the house, and in this process, it releases the heat that was absorbed underground. Electricity is of course required to drive a heat pump, but far less electrical power is needed to do this than would be required to heat the house directly.

In general, solar design of houses and other buildings requires an initial investment, but over time, the investment is amply repaid through energy savings.

Solar systems for heating water and cooking

Solar heat collectors are are already in common use to supply hot water for families or to heat swimming pools. A common form of the solar heat collector consists of a flat, blackened heat-collecting plate to which tubes containing the fluid to be heated are connected. The plate is insulated from the atmosphere by a layer of air (in some cases a partial vacuum) above which there is a sheet of glass. Water flowing through the tubes is collected in a tank whenever it is hotter than the water already there. In cases where there is a danger of freezing, the heated fluid may contain antifreeze, and it may then exchange heat with water in the collection tank. Systems of this kind can function even in climates

Figure 3.14: **Rows of wind turbines.**

as unfavorable as that of Northern Europe, although during winter months they must be supplemented by conventional water-heaters.

In the developing countries, wood is often used for cooking, and the result is sometimes deforestation, soil erosion and desertification. In order to supply an alternative, many designs for solar cooking have been developed. Often the designs are very simple, and many are both easy and inexpensive to build, the starting materials being aluminum foil and cardboard boxes.

Wind energy

Wind parks in favorable locations, using modern wind turbines, are able to generate 10 MW_e/km^2 or 10 W_e/m^2. Often wind farms are placed in offshore locations. When they are on land, the area between the turbines can be utilized for other purposes, for example for pasturage. For a country like Denmark, with good wind potential but cloudy skies, wind turbines can be expected to play a more important future role than photovoltaics. Denmark is already a world leader both in manufacturing and in using wind turbines. Today, on windy days, 100% of all electricity used in Denmark is generated by wind power, and the export of wind turbines makes a major contribution to the Danish economy. The use of wind power is currently growing at the rate of 38% per year. In the United States, it is the fastest-growing form of electricity generation.

The location of wind parks is important, since the energy obtainable from wind is proportional to the cube of the wind velocity. We can understand this cubic relationship by remembering that the kinetic energy of a moving object is proportional to the square

Figure 3.15: **Vertical axis wind turbines.**

of its velocity multiplied by the mass. Since the mass of air moving past a wind turbine is proportional to the wind velocity, the result is the cubic relationship just mentioned.

Before the decision is made to locate a wind park in a particular place, the wind velocity is usually carefully measured and recorded over an entire year. For locations on land, mountain passes are often very favorable locations, since wind velocities increase with altitude, and since the wind is concentrated in the passes by the mountain barrier. Other favorable locations include shorelines and offshore locations on sand bars. This is because onshore winds result when warm air rising from land heated by the sun is replaced by cool marine air. Depending on the season, the situation may be reversed at night, and an offshore wind may be produced if the water is warmer than the land.

The cost of wind-generated electrical power is currently lower than the cost of electricity generated by burning fossil fuels.

The "energy payback ratio" of a power installation is defined as the ratio of the energy produced by the installation over its lifetime, divided by the energy required to manufacture, construct, operate and decommission the installation. For wind turbines, this ratio is 17-39, compared with 11 for coal-burning plants. The construction energy of a wind turbine is usually paid back within three months.

Besides the propeller-like design for wind turbines there are also designs where the rotors turn about a vertical shaft. One such design was patented in 1927 by the French aeronautical engineer Georges Jean Marie Darrieus. The blades of a Darrieus wind turbine are airfoils similar to the wings of an aircraft. As the rotor turns in the wind, the stream of air striking the airfoils produces a force similar to the "lift" of an airplane wing. This

Figure 3.16: **Wind turbines on the Danish island of Samsø The island was the first in the world to achieve 100% renewable energy.**

force pushes the rotor in the direction that it is already moving. The Darrieus design has some advantages over conventional wind turbine design, since the generator can be placed at the bottom of the vertical shaft, where it may be more easily serviced. Furthermore, the vertical shaft can be lighter than the shaft needed to support a conventional wind turbine.

One problem with wind power is that it comes intermittently, and demand for electrical power does not necessarily come at times when the wind is blowing most strongly. To deal with the problem of intermittency, wind power can be combined with other electrical power sources in a grid. Alternatively, the energy generated can be stored, for example by pumped hydroelectric storage or by using hydrogen technology, as will be discussed below.

Bird lovers complain that birds are sometimes killed by rotor blades. This is true, but the number killed is small. For example, in the United States, about 70,000 birds per year are killed by turbines, but this must be compared with 57 million birds killed by automobiles and 97.5 million killed by collisions with plate glass.

The aesthetic aspects of wind turbines also come into the debate. Perhaps in the future, as wind power becomes more and more a necessity and less a matter of choice, this will be seen as a "luxury argument".

A Danish island reaches 100% renewable energy

The Danish island of Samsø is only 112 square kilometers in size, and its population numbers only 4,300. Nevertheless, it has a unique distinction. Samsø was the first closed land area to declare its intention of relying entirely on renewable energy, and it has now achieved this aim, provided that one stretches the definitions slightly.

Figure 3.17: **Hydroelectric power does not suffer from the problem of intermittency, but may sometimes produce undesirable social and ecological impacts.**

In 1997, the Danish Ministry of Environment and Energy decided to sponsor a renewable-energy contest. In order to enter, communities had to submit plans for how they could make a transition from fossil fuels to renewable energy. An engineer (who didn't live there) thought he knew how Samsø could do this, and together with the island's mayor he submitted a plan which won the contest. As a result, the islanders became interested in renewable energy. They switched from furnaces to heat pumps, and formed cooperatives for the construction of windmill parks in the sea near to the island. By 2005, Samsø was producing, from renewable sources, more energy than it was using. The islanders still had gasoline-driven automobiles, but they exported from their windmill parks an amount of electrical energy that balanced the fossil fuel energy that they imported. This is a story that can give us hope for the future, although a farming community like Samsø cannot serve as a model for the world.

Hydroelectric power

In 2015, hydroelectric power supplied 16.6% of all electrical power, and 70% of the electrical power generated from renewable energy. In the developed countries, the potential for increasing this percentage is small, because most of the suitable sites for dams are already in use. Mountainous regions of course have the greatest potential for hydroelectric power, and this correlates well with the fact that virtually all of the electricity generated in Norway comes from hydro, while in Iceland and Austria the figures are respectively 83% and 67%. Among the large hydroelectric power stations now in use are the La Grande complex in Canada (16 GW_e) and the Itapú station on the border between Brazil and Paraguay (14 GW_e). The Three Gorges Dam in China produces 18.2 GW_e.

Table 3.1: Technical potential and utilization of hydropower. (Data from World Energy Council, 2003.)

Region	Technical potential	Annual output	Percent used
Asia	0.5814 TW_e	0.0653 TW_e	11%
S. America	0.3187 TW_e	0.0579 TW_e	18%
Europe	0.3089 TW_e	0.0832 TW_e	27%
Africa	0.2155 TW_e	0.0091 TW_e	4%
N. America	0.1904 TW_e	0.0759 TW_e	40%
Oceania	0.0265 TW_e	0.0046 TW_e	17%
World	1.6414 TW_e	0.2960 TW_e	18%

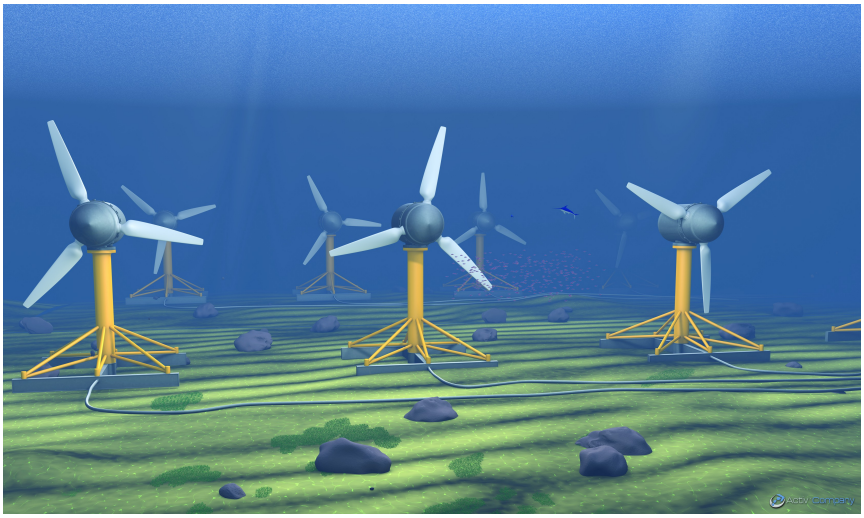

Figure 3.18: **Underwater turbines can make use of the energy of ocean currents.**

Even in regions where the percentage of hydro in electricity generation is not so high, it plays an important role because hydropower can be used selectively at moments of peak demand. Pumping of water into reservoirs can also be used to store energy.

The creation of lakes behind new dams in developing countries often involves problems, for example relocation of people living on land that will be covered by water, and loss of the land for other purposes[16]. However the energy gain per unit area of lake can be very large - over 100 W_e/m^2. Fish ladders can be used to enable fish to reach their spawning grounds above dams. In addition to generating electrical power, dams often play useful roles in flood control and irrigation.

At present, hydroelectric power is used in energy-intensive industrial processes, such as the production of aluminum. However, as the global energy crisis becomes more severe, we can expect that metals derived from electrolysis, such as aluminum and magnesium, will be very largely replaced by other materials, because the world will no longer be able to afford the energy needed to produce them.

Energy from the ocean

Tidal power

The twice-daily flow of the tides can be harnessed to produce electrical power. Ultimately tidal energy comes from the rotation of the earth and its interaction with the moon's gravitational field. The earth's rotation is very gradually slowing because of tidal friction, and the moon is gradually receding from the earth, but this process will take such an extremely long time that tidal energy can be thought of as renewable.

[16]Over a million people were displaced by the construction of the Three Gorges Dam in China, and many sites of cultural value were lost

There are two basic methods for harnessing tidal power. One can build barriers that create level differences between two bodies of water, and derive hydroelectric power from the head of water thus created. Alternatively it is possible to place the blades of turbines in a tidal stream. The blades are then turned by the tidal current in much the same way that the blades of a wind turbine are turned by currents of air.

There are plans for using the second method on an extremely large scale in Cook Strait, near New Zealand. A company founded by David Beach and Chris Bathurst plans to anchor 7,000 turbines to the sea floor of Cook Strait in such a way that they will float 40 meters below the surface. Beach and Bathurst say that in this position, the turbines will be safe from the effects of earthquakes and storms. The tidal flow through Cook Strait is so great that the scheme could supply all of New Zealand's electricity if the project is completed on the scale visualized by its founders.

Choosing the proper location for tidal power stations is important, since the height of tides depends on the configuration of the land. For example, tides of 17 meters occur in the Bay of Fundy, at the upper end of the Gulf of Maine, between New Brunswick and Nova Scotia. Here tidal waves are funneled into the bay, creating a resonance that results in the world's greatest level difference between high an low tides. An 18 MW_e dam-type tidal power generation station already exists at Annapolis River, Nova Scotia, and there are proposals to increase the use of tidal power in the Bay of Fundy. Some proposals involve turbines in the tidal stream, similar to those proposed for use in the Cook Strait.

In the future, favorable locations for tidal power may be exploited to their full potentialities, even thought the output of electrical energy exceeds local needs. The excess energy can be stored in the form of hydrogen (see below) and exported to regions deficient in renewable energy resources.

Wave energy

At present, the utilization of wave energy is in an experimental stage. In Portugal, there are plans for a wave farm using the Pelamis Wave Energy Converter. The Pelamis is a long floating tube with two or more rigid sections joined by hinges. The tube is tethered with its axis in the direction of wave propagation. The bending between sections resulting from passing waves is utilized to drive high pressure oil through hydraulic motors coupled to electrical generators. Each wave farm in the Portuguese project is planned to use three Pelamis converters, each capable of producing 750 kW_e. Thus the total output of each wave farm will be 2.25 MW_e.

Another experimental wave energy converter is Salter's Duck, invented in the 1970's by Prof. Stephen Salter of the University of Edinburgh, but still being developed and improved. Like the Pelamis, the Duck is also cylindrical in shape, but the axis of the cylinder is parallel to the wave front, i.e. perpendicular to the direction of wave motion. A floating cam, attached to the cylinder, rises and falls as a wave passes, driving hydraulic motors within the cylinder. Salter's Duck is capable of using as much as 65% of the wave's energy.

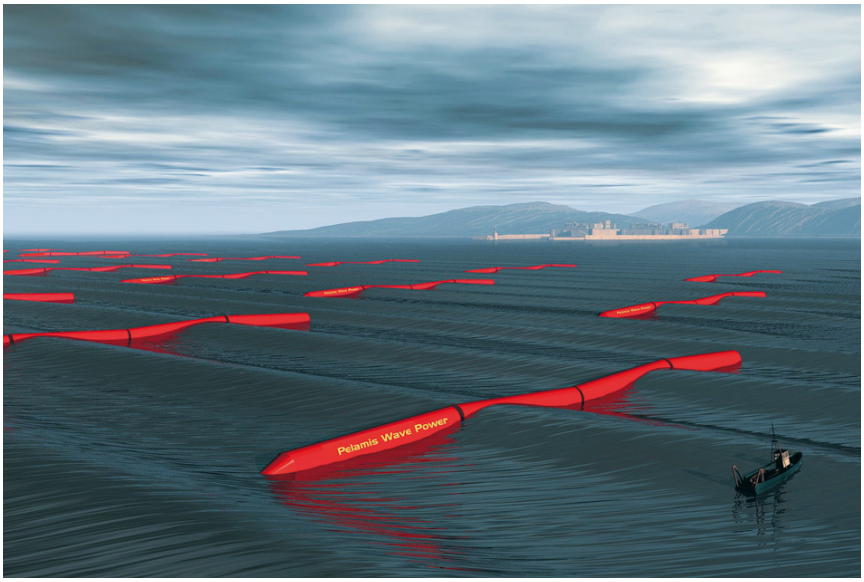

Figure 3.19: **The Pelamis wave energy transformer floats on the ocean like a giant sea snake. It consists of several segments which move against each other and build up hydraulic pressure. This in turn drives a turbine. A new Pelamis generation is currently under construction.**

The energy potentially available from waves is very large, amounting to as much as 100 kilowatts per meter of wave front in the best locations.

Ocean thermal energy conversion

In tropical regions, the temperature of water at the ocean floor is much colder than water at the surface. In ocean thermal energy conversion, cold water is brought to the surface from depths as great as 1 km, and a heat engine is run between deep sea water at a very low temperature and surface water at a much higher temperature.

According to thermodynamics, the maximum efficiency of a heat engine operating between a cold reservoir at the absolute temperature T_C and a hot reservoir at the absolute temperature T_H is given by 1-T_C/T_H. In order to convert temperature on the centigrade scale to absolute temperature (degrees Kelvin) one must add 273 degrees. Thus the maximum efficiency of a heat engine operating between water at the temperature of 25 ^{o}C and water at 5 ^{o}C is 1-(5+273)/(25+273)=0.067 = 6.7%. The efficiency of heat engines is always less than the theoretical maximum because of various losses, such as the loss due to friction. The actual overall efficiencies of existing ocean thermal energy conversion (OTEC) stations are typically 1-3%. On the other hand, the amount of energy potentially available from differences between surface and bottom ocean temperatures is extremely large.

Since 1974, OTEC research has been conducted by the United States at the Natural Energy Laboratory of Hawaii. The Japanese government also supports OTEC research,

and India has established a 1 MW_e OTEC power station floating in the ocean near to Tamil Nadu.

Renewable energy from evaporation

A September 26, 2017 article by Ahmet-Hamdi Cavusoglu et al. in *Nature Communications* points to evaporation as a future source of renewable energy. Here are some excerpts from the article:

"About 50% of the solar energy absorbed at the Earth's surface drives evaporation, fueling the water cycle that affects various renewable energy resources, such as wind and hydropower. Recent advances demonstrate our nascent ability to convert evaporation energy into work, yet there is little understanding about the potential of this resource.

"Here we study the energy available from natural evaporation to predict the potential of this ubiquitous resource. We find that natural evaporation from open water surfaces could provide power densities comparable to current wind and solar technologies while cutting evaporative water losses by nearly half. We estimate up to 325 GW of power is potentially available in the United States. Strikingly, water's large heat capacity is sufficient to control power output by storing excess energy when demand is low, thus reducing intermittency and improving reliability. Our findings motivate the improvement of materials and devices that convert energy from evaporation...

"Recent advances in water responsive materials and devices demonstrate the ability to convert energy from evaporation into work. These materials perform work through a cycle of absorbing and rejecting water via evaporation. These water-responsive materials can be incorporated into evaporation-driven engines that harness energy when placed above a body of evaporating water. With improvements in energy conversion efficiency, such devices could become an avenue to harvest energy via natural evaporation from water reservoirs."

Ozgur Sahin, a biophysicist at Columbia, has developed technology that uses spores from the harmless soil-dwelling bacterium *B. subtilis* to absorb and release water when the relative humidity of the surrounding air changes. At high humidity, the spores take in water and expand, and at low humidity they release water and contract, acting like a muscle.

Biomass

Biomass is defined as any energy source based on biological materials produced by photosynthesis - for example wood, sugar beets, rapeseed oil, crop wastes, dung, urban organic wastes, processed sewage, etc. Using biomass for energy does not result in the net emission of CO_2, since the CO_2 released by burning the material had previously been absorbed from the atmosphere during photosynthesis. If the biological material had decayed instead of being burned, it would released the same amount of CO_2 as in the burning process.

The solar constant has the value 1.4 kilowatts/m^2. It represents the amount of solar

Figure 3.20: **Rapeseed is grown in several countries, including Denmark and the UK. Experimental Danish buses are already running on rapeseed oil.**

energy per unit area[17] that reaches the earth, before the sunlight has entered the atmosphere. Because the atmosphere reflects 6% and absorbs 16%, the peak power at sea level is reduced to 1.0 kW/m^2. Clouds also absorb and reflect sunlight. Average cloud cover reduces the energy of sunlight a further 36%. Also, we must take into account the fact that the sun's rays do not fall perpendicularly onto the earth's surface. The angle that they make with the surface depends on the time of day, the season and the latitude.

In Sweden, which lies at a northerly latitude, the solar energy per unit of horizontal area is less than for countries nearer the equator. Nevertheless, Göran Persson, during his term as Prime Minister of Sweden, announced that his government intends to make the country independent of imported oil by 2020 through a program that includes energy from biomass.

In his thesis, *Biomass in a Sustainable Energy System*, the Swedish researcher Pål Börjesson states that of various crops grown as biomass, the largest energy yields come from short-rotation forests (Salix viminalis, a species of willow) and sugar beet plantations. These have an energy yield of from 160 to 170 GJ$_t$ per hectare-year. (The subscript t means "thermal". Energy in the form of electricity is denoted by the subscript e). One can calculate that this is equivalent to about 0.5 MW$_t$/km^2, or 0.5 W$_t$/m^2. Thus, although 1.0 kW/m^2 of solar energy reaches the earth at noon at the equator, the trees growing in northerly Sweden can harvest a day-and-night and seasonal average of only 0.5 Watts of thermal energy per horizontal square meter[18]. Since Sweden's present primary energy use is approximately 0.04 TW$_t$, it follows that if no other sources of energy were used, a square area of Salix forest 290 kilometers on each side would supply Sweden's present energy needs. This corresponds to an area of 84,000 km^2, about 19% of Sweden's total area[19].

[17]The area is assumed to be perpendicular to the sun's rays.

[18]In tropical regions, the rate of biomass production can be more than double this amount.

[19]Additional land area would be needed to supply the energy required for planting, harvesting, trans-

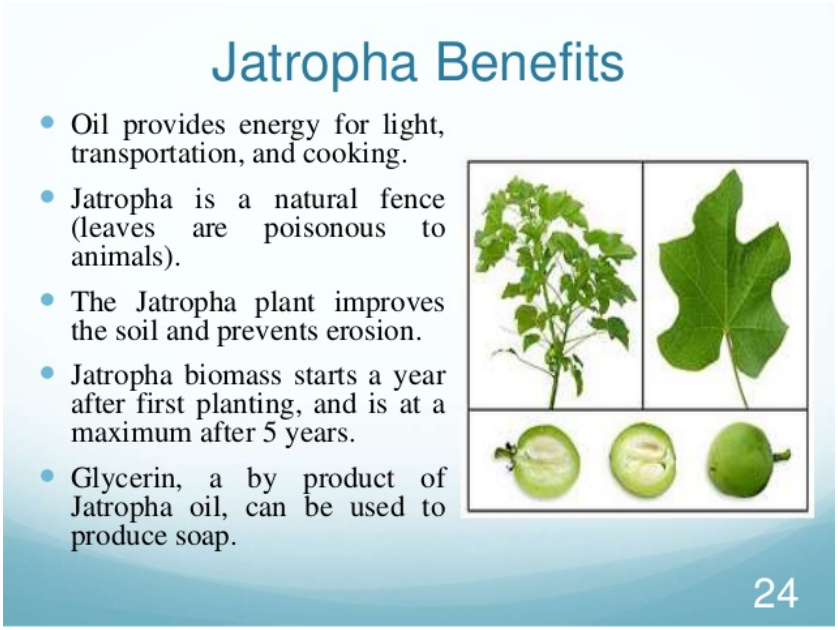

Figure 3.21: **In some countries, Jatropha is a promising source of biomass..**

Of course, Sweden's renewable energy program will not rely exclusively on energy crops, but on a mixture of sources, including biomass from municipal and agricultural wastes, hydropower, wind energy and solar energy.

At present, both Sweden and Finland derive about 30% of their electricity from biomass, which is largely in the form of waste from the forestry and paper industries of these two countries.

Despite their northerly location, the countries of Scandinavia have good potentialities for developing biomass as an energy source, since they have small population densities and adequate rainfall. In Denmark, biodiesel oil derived from rapeseed has been used as fuel for experimental buses. Rapeseed fields produce oil at the rate of between 1,000 and 1,300 liters per hectare-crop. The energy yield is 3.2 units of fuel product energy for every unit of fuel energy used to plant the rapeseed, and to harvest and process the oil. After the oil has been pressed from rapeseed, two-thirds of the seed remains as a protein-rich residue which can be fed to cattle.

Miscanthus is a grassy plant found in Asia and Africa. Some forms will also grow in Northern Europe, and it is being considered as an energy crop in the United Kingdom. Miscanthus can produce up to 18 dry tonnes per hectare-year, and it has the great advantage that it can be cultivated using ordinary farm machinery. The woody stems are very suitable for burning, since their water content is low (20-30%).

For some southerly countries, honge oil, derived from the plant *Pongamia pinnata* may prove to be a promising source of biomass energy. Studies conducted by Dr. Udishi Shrinivasa at the Indian Institute of Sciences in Bangalore indicate that honge oil can be

portation and utilization of the wood.

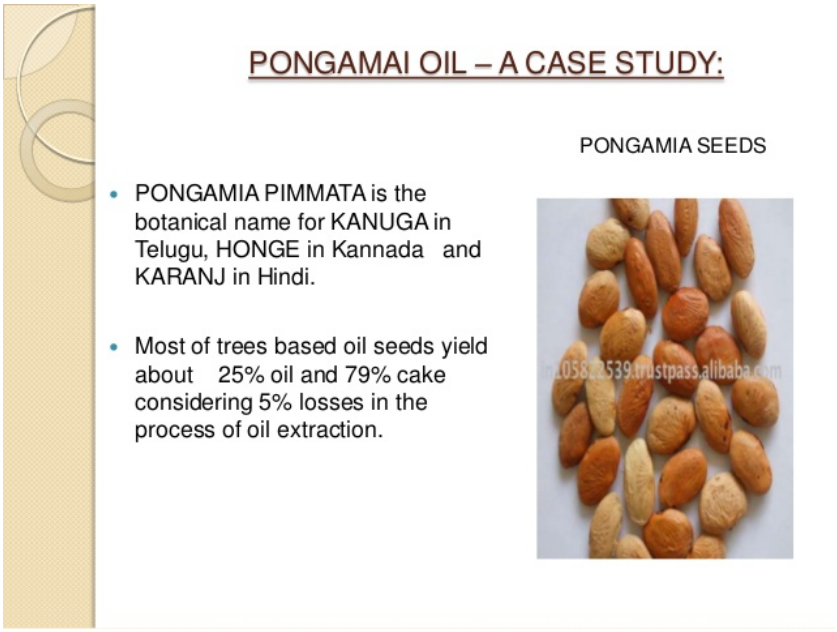

Figure 3.22: **The price of honge oil is quite competitive with other forms of oil.**

produced at the cost of $150 per ton. This price is quite competitive when compared with other potential fuel oils.

Recent studies have also focused on a species of algae that has an oil content of up to 50%. Algae can be grown in desert areas, where cloud cover is minimal. Farm waste and excess CO_2 from factories can be used to speed the growth of the algae.

It is possible that in the future, scientists will be able to create new species of algae that use the sun's energy to generate hydrogen gas. If this proves to be possible, the hydrogen gas may then be used to generate electricity in fuel cells, as will be discussed below in the section on hydrogen technology. Promising research along this line is already in progress at the University of California, Berkeley.

Biogas is defined as the mixture of gases produced by the anaerobic digestion of organic matter. This gas, which is rich in methane (CH_4), is produced in swamps and landfills, and in the treatment of organic wastes from farms and cities. The use of biogas as a fuel is important not only because it is a valuable energy source, but also because methane is a potent greenhouse gas, which should not be allowed to reach the atmosphere. Biogas produced from farm wastes can be used locally on the farm, for cooking and heating, etc. When biogas has been sufficiently cleaned so that it can be distributed in a pipeline, it is known as "renewable natural gas". It may then be distributed in the natural gas grid, or it can be compressed and used in internal combustion engines. Renewable natural gas can also be used in fuel cells, as will be discussed below in the section on Hydrogen Technology.

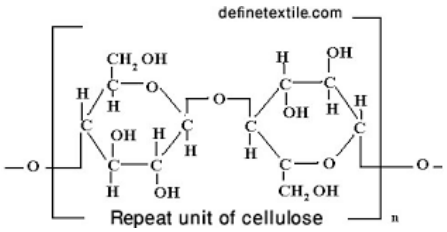

Figure 3.23: **Cellulose is a polysacheride. In other words, it is a long polymer whose subunits are sugars. The links between the sugar subunits in the chain can be broken, for example by the action of enzymes or acids. After this has been done, the resulting sugars can be fermented into alcohols, and these can be used to fuel motor vehicles or aircraft.**

Cellulostic ethanol

The fact that alcohols such as ethanol can be produced from cellulose has long been known.[20] In 1819, the French chemist Henri Braconnot demonstrated that cellulose could be broken down into sugars by treating it with sulfuric acid. The sugars thus produced could then be fermented into alcohols which could be used as liquid fuels.

In 1898, Germany built factories to commercialize this process, and shortly afterwards the same was done in the United States using a slightly different technique. These plants producing cellulostic ethanol operated during World War I, but the plants closed after the end of the war because of the cheapness and easy availability of fossil fuels. The production of cellulostic ethanol was revived during World War II.

During the last two decades, development of enzymatic techniques has supplied a better method of breaking the long cellulose polymer chain into sugars. In fact, it has recently become possible to use microbial enzymes both for this step and for the fermentation step.

In a September 9, 2008 article in the *MIT Technology Review*. Prachi Patal wrote: "New genetically modified bacteria could slash the costs of producing ethanol from cellulostic biomass, such as corn cobs and leaves, switchgrass, and paper pulp. The microbes produce ethanol at higher temperatures than are possible using yeast, which is currently employed to ferment sugar into the biofuel. The higher temperature more than halves the quantity of the costly enzymes needed to split cellulose into the sugars that the microbes can ferment. What's more, while yeast can only ferment glucose, 'this microorganism is good at using all the different sugars in biomass and can use them simultaneously and rapidly,' says Lee Lynd, an engineering professor at Dartmouth College, who led the microbe's development...

"Lynd wants to create microbes that would do it all: efficiently break down the cellulose and hemicellulose, and then ferment all the resulting sugars. Lynd, a cofounder of Mascoma, is working with colleagues at the startup, based in Cambridge, MA, to develop a simple one-step process for making cellulostic ethanol. In the combined process, a mixture of biomass and the microbes would go into a tank, and ethanol would come out."

Cellulostic ethanol has several advantages over alcohol derived from grain;

[20]See the Wikipedia article on *Cellulostic Ethanol*

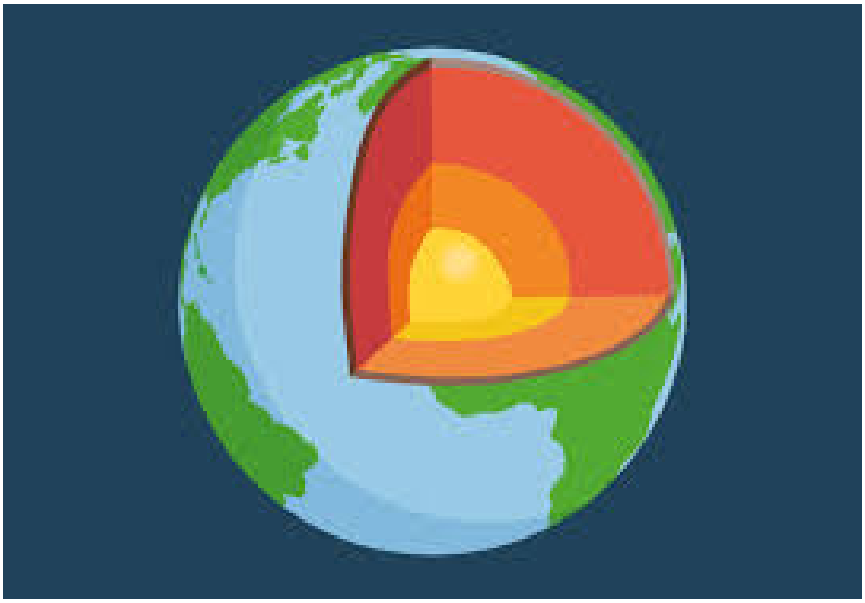

Figure 3.24: **The source of geothermal energy is the radioactive decay of elements deep within the earth.**

- Cellulostic ethanol avoids the food-fuel competition.
- The net greenhouse-gas-reducing effect of ethanol derived from grain is questionable.
- Cellulostic ethanol can use cardboard and paper waste as starting substances, thus reducing the quantity of trash in waste dumps.

Geothermal energy

The ultimate source of geothermal energy is the decay of radioactive nuclei in the interior of the earth. Because of the heat produced by this radioactive decay, the temperature of the earth's core is 4300 ^{o}C. The inner core is composed of solid iron, while the outer core consists of molten iron and sulfur compounds. Above the core is the mantle, which consists of a viscous liquid containing compounds of magnesium, iron, aluminum, silicon and oxygen. The temperature of the mantle gradually decreases from 3700 ^{o}C near the core to 1000 ^{o}C near the crust. The crust of the earth consists of relatively light solid rocks and it varies in thickness from 5 to 70 km.

The outward flow of heat from radioactive decay produces convection currents in the interior of the earth. These convection currents, interacting with the earth's rotation, produce patterns of flow similar to the trade winds of the atmosphere. One result of the currents of molten conducting material in the interior of the earth is the earth's magnetic field. The crust is divided into large sections called "tectonic plates", and the currents of molten material in the interior of the earth also drag the plates into collision with each other. At the boundaries, where the plates collide or split apart, volcanic activity

Figure 3.25: **The "ring of fire" is especially favorable for geothermal energy installations. The ring follows the western coasts of South America and North America to Alaska, After crossing the Bering Sea, it runs southward past Japan and Indonesia to New Zealand. Earthquakes and volcanic activity along this ring are produced by the collision of tectonic plates. Another strip-like region very favorable for geothermal installations follows Africa's Rift Valley northward through Turkey and Greece to Italy, while a third pass through Iceland.**

occurs. Volcanic regions near the tectonic plate boundaries are the best sites for collection of geothermal energy.

The entire Pacific Ocean is ringed by regions of volcanic and earthquake activity, the so-called Ring of Fire. This ring extends from Tierra del Fuego at the southernmost tip of South America, northward along the western coasts of both South America and North America to Alaska. The ring then crosses the Pacific at the line formed by the Aleutian Islands, and it reaches the Kamchatka Peninsula in Russia. From there it extends southward along the Kurile Island chain and across Japan to the Philippine Islands, Indonesia and New Zealand. Many of the islands of the Pacific are volcanic in nature. Another important region of volcanic activity extends northward along the Rift Valley of Africa to Turkey, Greece and Italy. In the Central Atlantic region, two tectonic plates are splitting apart, thus producing the volcanic activity of Iceland. All of these regions are very favorable for the collection of geothermal power.

The average rate at which the energy created by radioactive decay in the interior of the earth is transported to the surface is 0.06 W_t/m^2. However, in volcanic regions near the boundaries of tectonic plates, the rate at which the energy is conducted to the surface is much higher - typically 0.3 W_t/m^2. If we insert these figures into the thermal conductivity law

$$q = K_T \frac{\Delta T}{z}$$

we can obtain an understanding of the types of geothermal resources available throughout

the world. In the thermal conductivity equation, q is the power conducted per unit area, while K_T is the thermal conductivity of the material through the energy is passing. For sandstones, limestones and most crystalline rocks, thermal conductivities are in the range 2.5-3.5 $W_t/(m\ ^oC)$. Inserting these values into the thermal conductivity equation, we find that in regions near tectonic plate boundaries we can reach temperatures of 200 ^oC by drilling only 2 kilometers into rocks of the types named above. If the strata at that depth contain water, it will be in the form of highly-compressed steam. Such a geothermal resource is called a *high-enthalpy* resource[21].

In addition to high-enthalpy geothermal resources there are *low-enthalpy* resources in nonvolcanic regions of the world, especially in basins covered by sedimentary rocks. Clays and shales have a low thermal conductivity, typically 1-2 $W_t/(m\ ^oC)$. When we combine these figures with the global average geothermal power transmission, $q = 0.06\ W_t/m^2$, the thermal conduction equation tells us that $\Delta T/z = 0.04\ ^oC/m$. In such a region the geothermal resources may not be suitable for the generation of electrical power, but nevertheless adequate for heating buildings. The Creil district heating scheme north of Paris is an example of a project where geothermal energy from a low enthalpy resource is used for heating buildings.

The total quantity of geothermal electrical power produced in the world today is 8 GW_e, with an additional 16 GW_t used for heating houses and buildings. In the United States alone, 2.7 GW_e are derived from geothermal sources. In some countries, for example Iceland and Canada, geothermal energy is used both for electrical power generation and for heating houses.

There are three methods for obtaining geothermal power in common use today: Deep wells may yield dry steam, which can be used directly to drive turbines. Alternatively water so hot that it boils when brought to the surface may be pumped from deep wells in volcanic regions. The steam is then used to drive turbines. Finally, if the water from geothermal wells is less hot, it may be used in binary plants, where its heat is exchanged with an organic fluid which then boils. In this last method, the organic vapor drives the turbines. In all three methods, water is pumped back into the wells to be reheated. The largest dry steam field in the world is The Geysers, 145 kilometers north of San Francisco, which produces 1,000 MW_e.

There is a fourth method of obtaining geothermal energy, in which water is pumped down from the surface and is heated by hot dry rocks. In order to obtain a sufficiently large area for heat exchange the fissure systems in the rocks must be augmented, for example by pumping water down at high pressures several hundred meters away from the collection well. The European Union has established an experimental station at Soultz-sous-Forets in the Upper Rhine to explore this technique. The experiments performed at Soultz will determine whether the "hot dry rock" method can be made economically viable. If so, it can potentially offer the world a very important source of renewable energy.

The molten lava of volcanoes also offers a potential source of geothermal energy that

[21]Enthalpy $\equiv H \equiv U + PV$ is a thermodynamic quantity that takes into account not only the internal energy U of a gas, but also energy PV that may be obtained by allowing it to expand.

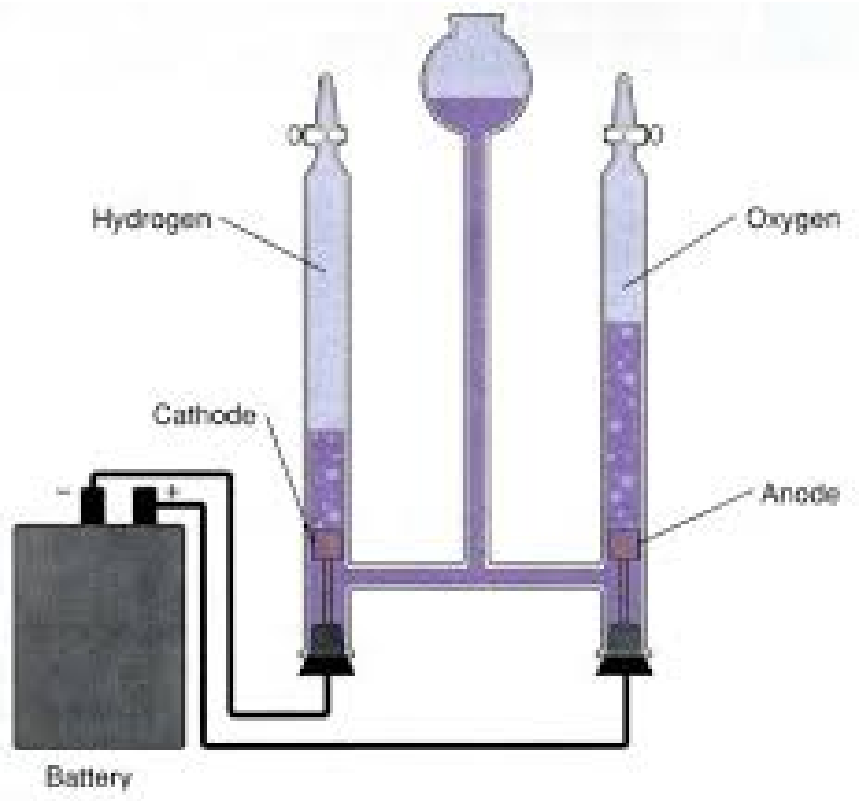

Figure 3.26: **Electrolysis of water.**

may become available in the future, but at present, no technology has been developed that is capable of using it.

Hydrogen technologies

Electrolysis of water

When water containing a little acid is placed in a container with two electrodes and subjected to an external direct current voltage greater than 1.23 Volts, bubbles of hydrogen gas form at one electrode (the cathode), while bubbles of oxygen gas form at the other electrode (the anode). At the cathode, the half-reaction

$$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^- \qquad E^0 = -1.23\ Volts$$

takes place, while at the anode, the half-reaction

$$4H^+(aq) + 4e^- \rightarrow 2H_2(g) \qquad E^0 = 0$$

occurs.

Half-reactions differ from ordinary chemical reactions in containing electrons either as reactants or as products. In electrochemical reactions, such as the electrolysis of water,

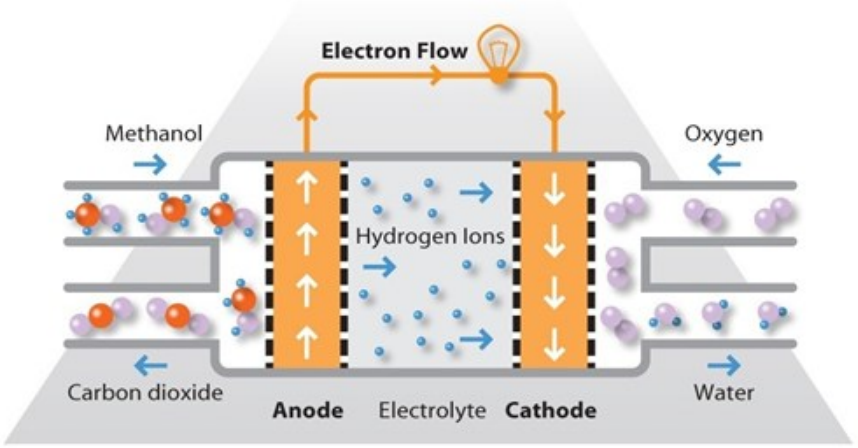

Figure 3.27: **A methanol fuel cell.**

these electrons are either supplied or removed by the external circuit. When the two half-reactions are added together, we obtain the total reaction:

$$2H_2O(l) \rightarrow O_2(g) + 2H_2(g) \qquad E^0 = -1.23\ Volts$$

Notice that $4H^+$ and $4e^-$ cancel out when the two half-reactions are added. The total reaction does not occur spontaneously, but it can be driven by an external potential E, provided that the magnitude of E is greater than 1.23 volts.

When this experiment is performed in the laboratory, platinum is often used for the electrodes, but electrolysis of water can also be performed using electrodes made of graphite.

Electrolysis of water to produce hydrogen gas has been proposed as a method for energy storage in a future renewable energy system. For example, it might be used to store energy generated by photovoltaics in desert areas of the world. Compressed hydrogen gas could then be transported to other regions and used in fuel cells. Electrolysis of water and storage of hydrogen could also be used to solve the problem of intermittency associated with wind energy or solar energy.

Half reactions

Chemical reactions in which one or more electrons are transferred are called *oxidation-reduction reactions*. Any reaction of this type can be used in a fuel cell. As an example, we can consider the oxidation-reduction reaction in which solid lithium metal reacts with fluorine gas;

$$2Li_{(s)} + F_{2(g)} \rightarrow 2LiF_{(s)}$$

This reaction can be split into two half-reactions,

$$Li_{(s)} \rightarrow Li^+ + e^- \qquad E_0 = -3.040\ V$$

and

$$F_{2(g)} \rightarrow 2F^+ + 2e^- \qquad E_0 = 2.87\ V$$

The quantity E_0 which characterizes these half-reactions is called *standard potential* of the half-reaction, and it is measured in Volts. If the oxidation-reduction reaction is used as the basis of a fuel cell, the voltage of the cell is the difference between the two standard potentials. In the lithium fluoride example, it is

$$2.87\ V - (-3.040\ V) = 5.91\ V$$

Here are a few more half-reactions and their standard potentials:

$$\begin{array}{cc}
K^+ + e^- \rightarrow\ K_{(s)} & E_0 = -2.924\ V \\
Na^+ + e^- \rightarrow Na_{(s)} & E_0 = -2.7144\ V \\
2H_2O + 2e^- \rightarrow H_20 + 2OH^- & E_0 = -0.828\ V \\
Zn^{2+} + 2e^- \rightarrow Zn_{(s)} & E_0 = -0.7621\ V \\
Fe^{2+} + 2e^- \rightarrow Fe_{(s)} & E_0 = -0.440\ V \\
Pb^{2+} + 2e^- \rightarrow Pb_{(s)} & E_0 = -0.1266\ V \\
2H^+ + 2e^- \rightarrow H_{2(g)} & E_0 \equiv 0.0000\ V \\
Cu^{2+} + 2e^- \rightarrow Cu_{(s)} & E_0 = +0.3394\ V \\
I_{2(s)} + 2e^- \rightarrow 2I^- & E_0 = +0.535\ V \\
Fe^{3+} + e^- \rightarrow Fe^{2+} & E_0 = +0.769\ V \\
Br_{2(l)} + 2e^- \rightarrow 2Br^- & E_0 = +1.0775\ V \\
O_{2(g)} + 4H^+ + 4e^- \rightarrow 2H_2O & E_0 = +1.2288\ V \\
Cl_{2(g)} + 2e^- \rightarrow 2Cl^- & E_0 = +1.3601\ V
\end{array}$$

Fuel cells are closely related to storage batteries. Essentially, when we recharge a storage battery we are just running a fuel cell backwards, applying an electrical potential which is sufficient to make a chemical reaction run in a direction opposite to the way that it would run spontaneously. When the charged battery is afterwards used to drive a vehicle or to power an electronic device, the reaction runs in the spontaneous direction, but the energy of the reaction, instead of being dissipated as heat, drives electrons through an external circuit and performs useful work.

3.11 Renewables are now much cheaper than fossil fuels!

According to an article written by Megan Darby and published in *The Guardian* on 26 January, 2016, "Solar power costs are tumbling so fast the technology is likely to fast outstrip mainstream energy forecasts.

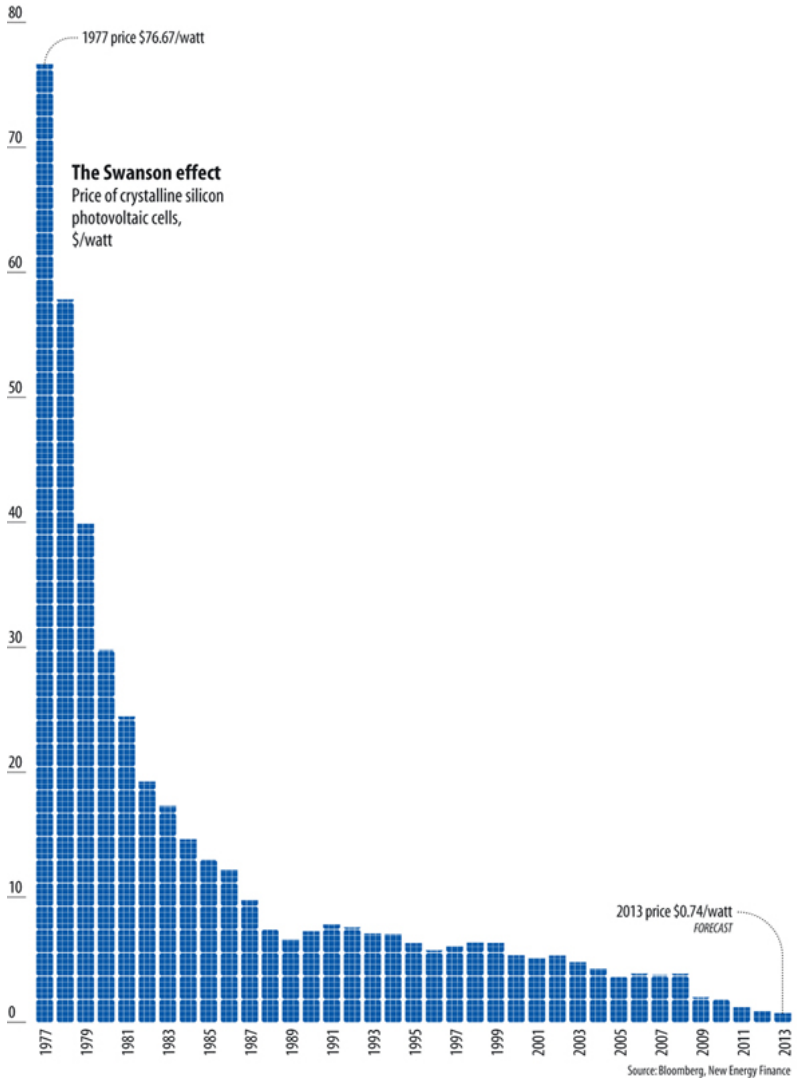

Figure 3.28: **The cost of photovoltaic cell panels is falling rapidly**

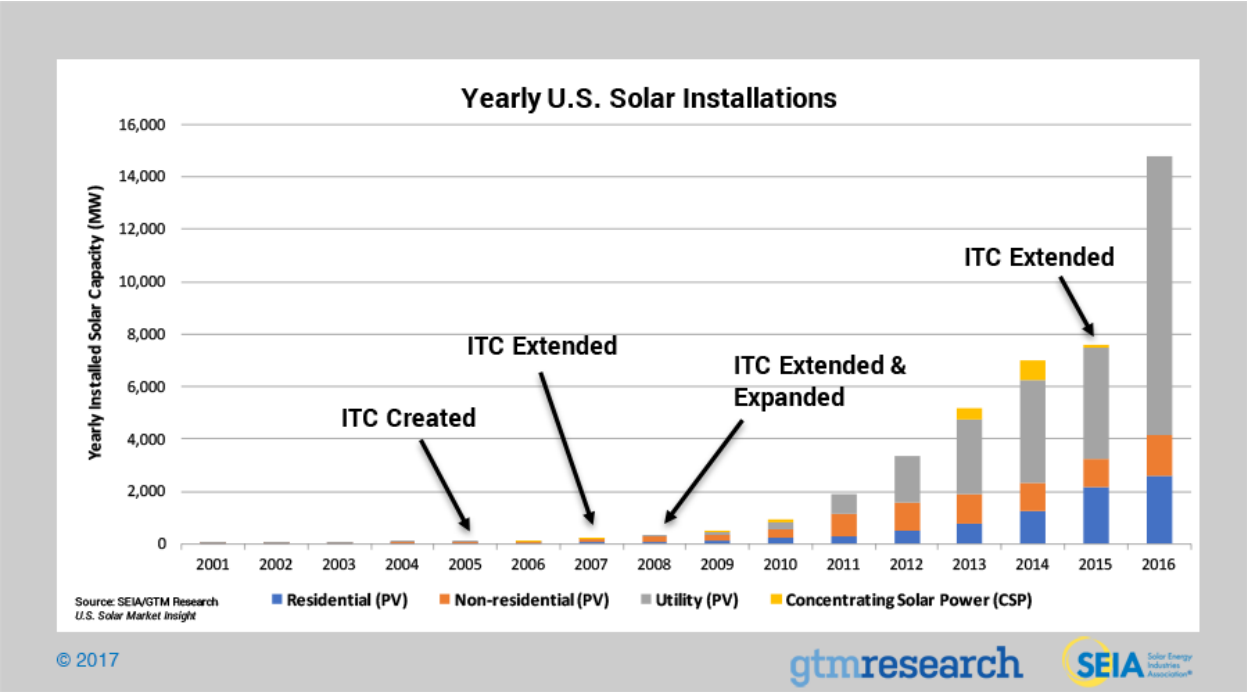

Figure 3.29: **Driven by falling prices, new solar installations in the United States are increasing rapidly. The acronym ITC stands for Solar Investment Tax Credit. Commercial prices have fallen by 58% since 2012 and by 16% in the last year**

"That is the conclusion of Oxford University researchers, based on a new forecasting model published in Research Policy[22].

"Commercial prices have fallen by 58% since 2012 and by 16

"Since the 1980s, panels to generate electricity from sunshine have got 10% cheaper each year. That is likely to continue, the study said, putting solar on course to meet 20% of global energy needs by 2027.' '

3.12 Lester R. Brown

In December 2008, Lester R. Brown called attention to the following facts:

- The renewable energy industry - wind, solar, geothermal - are expanding by over 30 percent yearly;
- There are now, in the U.S., 24,000 megawatts of wind generating capacity online, but there is a staggering 225,000 megawatts of planned wind farms;

[22]http://www.sciencedirect.com/science/article/pii/S0048733315001699

Figure 3.30: **Lester R. Brown, born in 1934, is the author of more than 50 books, and he has been called "...one of the world's most influential thinkers" (Washington Post). He is the founder of the Worldwatch Institute and the Earth Policy Institute. Books produced by Brown and his coworkers at the EPI can be freely downloaded and circulated. The 2015 book *The Great Transition: Shifting From Fossil Fuels to Solar and Wind Energy* can be freely downloaded from the following link: http://www.earth-policy.org/books/tgt**

- What is needed is a World War II-type mobilization to produce electric-powered cars that will operate at an equivalent gas cost of $1 per gallon (Replacing each SUV with a plug-in hybrid could save $20,000 of oil imports over its lifetime);

3.13 Reforming our food and agricultural systems

The medical journal The Lancet recently published a report which aimed at changing the diets of people throughout the world. The commission which produced the report brought together 37 experts in agriculture, environmental sustainability, human health, and political science from 16 countries. Over three years, they developed the "planetary health diet," which aims to address the global food system's devastating environmental impact as well as mass malnutrition.

"The food we eat and how we produce it determines the health of people and the planet, and we are currently getting this seriously wrong," declared Tim Lang, a co-author of the EAT-Lancet Commission and professor at City, University of London. "We need a significant overhaul, changing the global food system on a scale not seen before in ways appropriate to each country's circumstances."

"To be healthy," he explained, "diets must have an appropriate calorie intake and consist of a variety of plant-based foods, low amounts of animal-based foods, unsaturated rather than saturated fats, and few refined grains, highly processed foods, and added sugars."

"Humanity now poses a threat to the stability of the planet," co-lead commissioner Johan Rockström of the Stockholm Resilience Center told the Guardian. "[This requires] nothing less than a new global agricultural revolution."

Here are some of the commission's recommendations:

1. Seek international and national commitment to shift toward healthy diets that feature more plant-based foods - including fruits, vegetables, nuts, seeds, and whole grains - and less animal products.

2. Reorient agricultural priorities from producing high quantities of food to producing healthy food that nurtures human health and supports environmental sustainability.

3. Sustainably intensify food production to increase high-quality output with a series of reforms that include becoming a net carbon sink from 2040 forward to align with the goals of the Paris climate agreement.

4. Strong and coordinated governance of land and oceans, including by implementing a "Half Earth" strategy for biodiversity conservation.

5. At least halve food losses and waste, in line with the U.N. Sustainable Development Goals (SDGs), on both the production side and the consumption side.

Figure 3.31: **We should eat more vegetables, fruits, whole grains and nuts, while consuming much less meat and dairy products. Beef is especially damaging to the global environment.**

Here are some excerpts from a 16 January 2019 article in The Guardian by Damian Cammeron:

Globally, the diet requires red meat and sugar consumption to be cut by half, while vegetables, fruit, pulses and nuts must double. But in specific places the changes are stark. North Americans need to eat 84% less red meat but six times more beans and lentils. For Europeans, eating 77% less red meat and 15 times more nuts and seeds meets the guidelines.

The diet is a "win-win", according to the scientists, as it would save at least 11 million people a year from deaths caused by unhealthy food, while preventing the collapse of the natural world that humanity depends upon. With 10 billion people expected to live on Earth by 2050, a continuation of today's unsustainable diets would inevitably mean even greater health problems and severe global warming.

Unhealthy diets are the leading cause of ill health worldwide, with 800 million people currently hungry, 2 billion malnourished and further 2 billion people overweight or obese. The world's science academies recently concluded that the food system is broken. Industrial agriculture is also devastating the environment, as forests are razed and billions of cattle emit climate-warming methane.

Future agriculture

When the major glaciers in the Himalayas have melted, they will no longer be able to give India and China summer water supplies; rising oceans will drown much agricultural land; and aridity will reduce the output of many regions that now produce much of the world's grain. Falling water tables in overdrawn aquifers, and loss of topsoil will add to the problem. We should be aware of the threat of a serious global food crisis in the 21st century if we are to have a chance of avoiding it.

The term *ecological footprint* was introduced by William Rees and Mathis Wackernagel in the early 1990's to compare demands on the environment with the earth's capacity to regenerate. In 2015, humanity used environmental resources at such a rate that it would take 1.6 earths to renew them. In other words, we have already exceeded the earth's carrying capacity. Since eliminating the poverty that characterizes much of the world today will require more resources per capita, rather than less. it seems likely that in the era beyond fossil fuels, the optimum global population will be considerably less than the present population of the world.

Limitations on cropland

In 1944 the Norwegian-American plant geneticist Norman Borlaug was sent to Mexico by the Rockefeller Foundation to try to produce new wheat varieties that might increase Mexico's agricultural output. Borlaug's dedicated work on this project was spectacularly successful. He remained with the project for 16 years, and his group made 6,000 individual crossings of wheat varieties to produce high-yield disease-resistant strains.

In 1963, Borlaug visited India, bringing with him 100 kg. of seeds from each of his most promising wheat strains. After testing these strains in Asia, he imported 450 tons of the Lerma Rojo and Sonora 64 varieties: 250 tons for Pakistan and 200 for India. By 1968, the success of these varieties was so great that school buildings had to be commandeered to store the output. Borlaug's work began to be called a "Green Revolution". In India, the research on high-yield crops was continued and expanded by Prof. M.S. Swaminathan and his co-workers. The work of Green Revolution scientists, such Norman Borlaug and M.S. Swaminathan, has been credited with saving the lives of as many as a billion people.

Despite these successes, Borlaug believes that the problem of population growth is still a serious one. "Africa and the former Soviet republics", Borlaug states, "and the Cerrado, are the last frontiers. After they are in use, the world will have no additional sizable blocks of arable land left to put into production, unless you are willing to level whole forests, which you should not do. So, future food-production increases will have to come from higher yields. And though I have no doubt that yields will keep going up, whether they can go up enough to feed the population monster is another matter. Unless progress with agricultural yields remains very strong, the next century will experience human misery that, on a sheer numerical scale, will exceed the worst of everything that has come before."

With regard to the prospect of increasing the area of cropland, a report by the United Nations Food and Agricultural Organization (Provisional Indicative World Plan for Agricultural Development, FAO, Rome, 1970) states that "In Southern Asia,... in some countries of Eastern Asia, in the Near East and North Africa... there is almost no scope for expanding agricultural area... In the drier regions, it will even be necessary to return to permanent pasture the land that is marginal and submarginal for cultivation. In most of Latin America and Africa south of the Sahara, there are still considerable possibilities for expanding cultivated areas; but the costs of development are high, and it will often be more economical to intensify the utilization of areas already settled." Thus there is a possibility of increasing the area of cropland in Africa south of the Sahara and in Latin America, but only at the cost of heavy investment and at the additional cost of destruction of tropical rain forests.

Rather than an increase in the global area of cropland, we may encounter a future loss of cropland through soil erosion, salination, desertification, loss of topsoil, depletion of minerals in topsoil, urbanization and failure of water supplies. In China and in the Southwestern part of the United States, water tables are falling at an alarming rate. The Ogallala aquifer (which supplies water to many of the plains states in the central and southern parts of the United States) has a yearly overdraft of 160%.

In the 1950's, both the U.S.S.R and Turkey attempted to convert arid grasslands into wheat farms. In both cases, the attempts were defeated by drought and wind erosion, just as the wheat farms of Oklahoma were overcome by drought and dust in the 1930's. If irrigation of arid lands is not performed with care, salt may be deposited, so that the land is ruined for agriculture. This type of desertification can be seen, for example, in some parts of Pakistan. Another type of desertification can be seen in the Sahel region of Africa, south of the Sahara. Rapid population growth in the Sahel has led to overgrazing, destruction of trees, and wind erosion, so that the land has become unable to support even

its original population.

Especially worrying is a prediction of the International Panel on Climate Change concerning the effect of global warming on the availability of water: According to Model A1 of the IPCC, global warming may, by the 2050's, have reduced by as much as 30% the water available in large areas of world that now a large producers of grain.

Added to the agricultural and environmental problems, are problems of finance and distribution. Famines can occur even when grain is available somewhere in the world, because those who are threatened with starvation may not be able to pay for the grain, or for its transportation. The economic laws of supply and demand are not able to solve this type of problem. One says that there is no "demand" for the food (meaning demand in the economic sense), even though people are in fact starving.[23]

Energy-dependence of modern agriculture

A very serious problem with Green Revolution plant varieties is that they require heavy inputs of pesticides, fertilizers and irrigation. Because of this, the use of high-yield varieties contributes to social inequality, since only rich farmers can afford the necessary inputs. Monocultures, such as the Green Revolution varieties may also prove to be vulnerable to future epidemics of plant diseases, such as the epidemic that caused the Irish Potato Famine in 1845. Even more importantly, pesticides, fertilizers and irrigation all depend on the use of fossil fuels. One must therefore ask whether high agricultural yields can be maintained in the future, when fossil fuels are expected to become prohibitively scarce and expensive.

Modern agriculture has become highly dependent on fossil fuels, especially on petroleum and natural gas. This is especially true of production of the high-yield grain varieties introduced in the Green Revolution, since these require especially large inputs of fertilizers, pesticides and irrigation. Today, fertilizers are produced using oil and natural gas, while pesticides are synthesized from petroleum feedstocks, and irrigation is driven by fossil fuel energy. Thus agriculture in the developed countries has become a process where inputs of fossil fuel energy are converted into food calories.

The ratio of the fossil fuel energy inputs to the food calorie outputs depends on how many energy-using elements of food production are included in the accounting. David Pimental and Mario Giampietro of Cornell University estimated in 1994 that U.S. agriculture required 0.7 kcal of fossil fuel energy inputs to produce 1.0 kcal of food energy. However, this figure was based on U.N. statistics that did not include fertilizer feedstocks, pesticide feed-stocks, energy and machinery for drying crops, or electricity, construction and maintenance of farm buildings. A more accurate calculation, including these inputs, gives an

[23] http://www.independent.co.uk/environment/climate-change/society-will-collapse-by-2040-due-to-catastrophic-food-shortages-says-study-10336406.html
http://www.truth-out.org/news/item/32131-the-new-climate-normal-abrupt-sea-level-rise-and-predictions-of-civilization-collapse
http://www.commondreams.org/views/2015/08/13/dignity-democracy-and-food-interview-frances-moore-lappe

input/output ratio of approximately 1.0. Finally, if the energy expended on transportation, packaging and retailing of food is included, Pimental and Giampietro found that the input/output ratio for the U.S. food system was approximately 10, and this figure did not include energy used for cooking.

The Brundtland Report's estimate of the global potential for food production assumes "that the area under food production can be around 1.5 billion hectares (3.7 billion acres - close to the present level), and that the average yields could go up to 5 tons of grain equivalent per hectare (as against the present average of 2 tons of grain equivalent)." In other words, the Brundtland Report assumes an increase in yields by a factor of 2.5. This would perhaps be possible if traditional agriculture could everywhere be replaced by energy-intensive modern agriculture using Green Revolution plant varieties. However, Pimental and Giampietro's studies show that modern energy-intensive agricultural techniques cannot be maintained after fossil fuels have been exhausted or after their use has been discontinued to avoid catastrophic climate change.

At the time when the Brundtland Report was written (1987), the global average of 2 tons of grain equivalent per hectare included much higher yields from the sector using modern agricultural methods. Since energy-intensive petroleum-based agriculture cannot be continued in the post-fossil-fuel era, future average crop yields will probably be much less than 2 tons of grain equivalent per hectare.

The 1987 global population was approximately 5 billion. This population was supported by 3 billion tons of grain equivalent per year. After fossil fuels have been exhausted, the total world agricultural output is likely to be considerably less than that, and therefore the population that it will be possible to support sustainably will probably be considerably less than 5 billion, assuming that our average daily per capita use of food calories remains the same, and assuming that the amount of cropland and pasturage remains the same (1.5 billion hectares cropland, 3.0 billion hectares pasturage).

The Brundtland Report points out that "The present (1987) global average consumption of plant energy for food, seed and animal feed amounts to 6,000 calories daily, with a range among countries of 3,000-15,000 calories, depending on the level of meat consumption." Thus there is a certain flexibility in the global population that can survive on a given total agricultural output. If the rich countries were willing to eat less meat, more people could be supported.[24]

[24]http://www.truth-out.org/news/item/32354-environmentalists-sue-epa-over-dead-zone-in-gulf-of-mexico

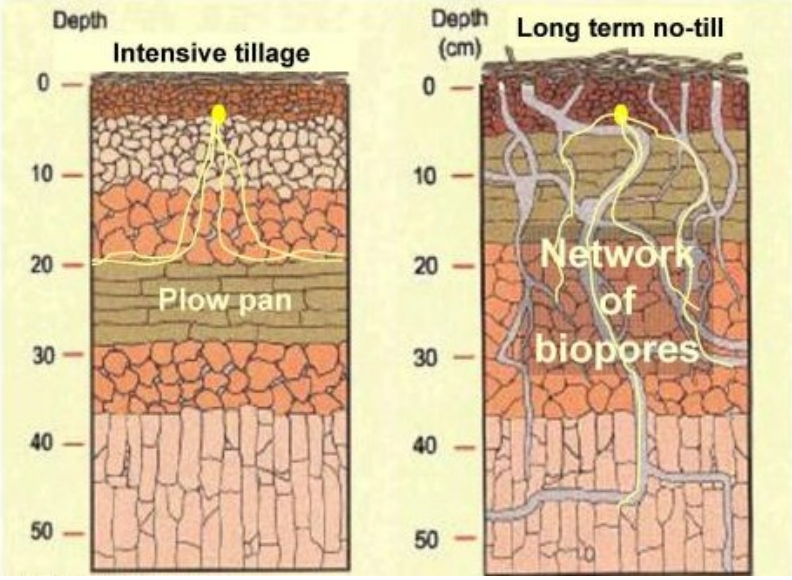

Figure 3.32: **Recent research on No-Till Agriculture points to many benefits that could result from this practice, especially higher CO_2 content in the topsoil.**

Effects of climate change on agriculture

a) The effect of temperature increase

There is a danger that when climate change causes both temperature increases and increased aridity in regions like the US grain belt, yields will be very much lowered. Of the three main grain types (corn, wheat and rice) corn is the most vulnerable to the direct effect of increases in temperature. One reason for this is the mechanism of pollination of corn: A pollen grain lands on one end of a corn-silk strand, and the germ cell must travel the length of the strand in order to fertilize the kernel. At high temperatures, the corn silk becomes dried out and withered, and is unable to fulfill its biological function. Furthermore, heat can cause the pores on the underside of the corn leaf to close, so that photosynthesis stops.

According to a study made by Mohan Wali and coworkers at Ohio State University, the photosynthetic activity of corn increases until the temperature reaches 20°C. It then remains constant until the temperature reaches 35°C, after which it declines. At 40°C and above, photosynthesis stops altogether.

Scientists in the Philippines report that the pollination of rice fails entirely at 40°C, leading to crop failures. Wheat yields are also markedly reduced by temperatures in this range.[25]

b) The effect of decreased rainfall

According to the Stern Report, some of the major grain-producing areas of the world

[25]http://ecowatch.com/2015/08/03/heat-wave-iran/

might loose up to 30% of their rainfall by 2050. These regions include much of the United States, Brazil, the Mediterranean region, Eastern Russia and Belarus, the Middle East, Southern Africa and Australia. Of course possibilities for agriculture may simultaneously increase in other regions, but the net effect of climate change on the world's food supply is predicted to be markedly negative.

c) Unsustainable use of groundwater

It may seem surprising that fresh water can be regarded as a non-renewable resource. However, groundwater in deep aquifers is often renewed very slowly. Sometimes renewal requires several thousand years. When the rate of withdrawal of groundwater exceeds the rate of renewal, the carrying capacity of the resource has been exceeded, and withdrawal of water becomes analogous to mining a mineral. However, it is more serious than ordinary mining because water is such a necessary support for life.

In many regions of the world today, groundwater is being withdrawn faster than it can be replenished, and important aquifers are being depleted. In China, for example, groundwater levels are falling at an alarming rate. Considerations of water supply in relation to population form the background for China's stringent population policy. At a recent lecture, Lester Brown of the Worldwatch Institute was asked by a member of the audience to name the resource for which shortages would most quickly become acute. Most of the audience expected him to name oil, but instead he replied "water".

Lester Brown then cited China's falling water table. He predicted that within decades, China would be unable to feed itself. He said that this would not cause hunger in China itself: Because of the strength of China's economy, the country would be able to purchase grain on the world market. However Chinese purchases of grain would raise the price, and put world grain out of reach of poor countries in Africa. Thus water shortages in China will produce famine in parts of Africa, Brown predicted.

Under many desert areas of the world are deeply buried water tables formed during glacial periods when the climate of these regions was wetter. These regions include the Middle East and large parts of Africa. Water can be withdrawn from such ancient reservoirs by deep wells and pumping, but only for a limited amount of time.

In oil-rich Saudi Arabia, petroenergy is used to drill wells for ancient water and to bring it to the surface. Much of this water is used to irrigate wheat fields, and this is done to such an extent that Saudi Arabia exports wheat. The country is, in effect, exporting its ancient heritage of water, a policy that it may, in time, regret. A similarly short-sighted project is Muammar Qaddafi's enormous pipeline, which will bring water from ancient sub-desert reservoirs to coastal cities.

In the United States, the great Ogallala aquifer is being overdrawn. This aquifer is an enormous stratum of water-saturated sand and gravel under-lying parts of northern Texas, Oklahoma, New Mexico, Kansas, Colorado, Nebraska, Wyoming and South Dakota. The average thickness of the aquifer is about 70 meters. The rate of water withdrawal from the aquifer exceeds the rate of recharge by a factor of eight.

Thus we can see that in many regions, the earth's present population is living on its inheritance of water, rather than its income. This fact, coupled with rapidly increasing pop-

ulations and climate change, may contribute to a very serious food crisis partway through the 21st century.

d) Glacial melting and summer water supplies

The summer water supplies of both China and India are threatened by the melting of glaciers. The Gangotri glacier, which is the principle glacier feeding India's great Ganges River, is reported to be melting at an accelerating rate, and it could disappear within a few decades. If this happens,the Ganges could become seasonal, flowing only during the monsoon season. Chinese agriculture is also threatened by disappearing Himalayan glaciers, in this case those on the Tibet-Quinghai Plateau. The respected Chinese glaciologist Yao Tandong estimates that the glaciers feeding the Yangtze and Yellow Rivers are disappearing at the rate of 7% per year.[26]

The Indus and Mekong Rivers will be similarly affected by the melting of glaciers. Lack of water during the summer season could have a serious impact on the irrigation.

Mature forests contain vast amounts of sequestered carbon, not only in their trees, but also in the carbon-rich soil of the forest floor. When a forest is logged or burned to make way for agriculture, this carbon is released into the atmosphere.

One fifth of the global carbon emissions are at present due to destruction of forests. This amount is greater than the CO_2 emissions for the world's transportation systems. An intact forest pumps water back into the atmosphere, increasing inland rainfall and benefiting agriculture. By contrast, deforestation, for example in the Amazonian rainforest, accelerates the flow of water back into the ocean, thus reducing inland rainfall. There is a danger that the Amazonian rainforest may be destroyed to such an extent that the region will become much more dry. If this happens, the forest may become vulnerable to fires produced by lightning strikes. This is one of the feedback loops against which the Stern Report warns: the drying and burning of the Amazonian rainforest may become irreversible, greatly accelerating climate change, if destruction of the forest proceeds beyond a certain point.

e) Erosion of topsoil.

Besides depending on an adequate supply of water, food production also depends on the condition of the thin layer of topsoil that covers the world's croplands. This topsoil is being degraded and eroded at an alarming rate: According to the World Resources Institute and the United Nations Environment Programme, "It is estimated that since World War II, 1.2 billion hectares... has suffered at least moderate degradation as a result of human activity. This is a vast area, roughly the size of China and India combined." This area is 27% of the total area currently devoted to agriculture. The report goes on to say that the degradation is greatest in Africa. The risk of topsoil erosion is greatest when marginal land is brought into cultivation, since marginal land is usually on steep hillsides which are vulnerable to water erosion when wild vegetation is removed.

[26]http://www.commondreams.org/news/2015/08/04/global-glaciers-melting-three-times-rate-20th-century

David Pimental and his associates at Cornell University pointed out in 1995 that "Because of erosion-associated loss of productivity and population growth, the per capita food supply has been reduced over the past 10 years and continues to fall. The Food and Agricultural Organization reports that the per capita production of grains which make up 80% of the world's food supply, has been declining since 1984...During the past 40 years nearly one-third of the world's cropland (1.5 billion hectares) has been abandoned because of soil erosion and degradation. Most of the replacement has come from marginal land made available by removing forests. Agriculture accounts for 80% of the annual deforestation."

Topsoil can also be degraded by the accumulation of salt when irrigation water evaporates. The worldwide area of irrigated land has increased from 8 million hectares in 1800 to more than 100 million hectares today. This land is especially important to the world food supply because it is carefully tended and yields are large in proportion to the area. To protect this land from salination, it should be irrigated in such a way that evaporation is minimized.

Finally cropland with valuable topsoil is being be lost to urban growth and highway development, a problem that is made more severe by growing populations and by economic growth.

Every year, more than 100,000 square kilometers of rain forest are cleared and burned, an area which corresponds to that of Switzerland and the Netherlands combined. Almost half of the world's tropical forests have already been destroyed. Ironically, the land thus cleared often becomes unsuitable for agriculture within a few years. Tropical soils may seem to be fertile when covered with luxuriant vegetation, but they are usually very poor in nutrients because of leeching by heavy rains. The nutrients which remain are contained in the vegetation itself; and when the forest cover is cut and burned, the nutrients are rapidly lost.

Often the remaining soil is rich in aluminum oxide and iron oxide. When such soils are exposed to oxygen and sun-baking, a rock-like substance called Laterite is formed.

3.14 Alexandria Ocasio-Cortez and the Green New Deal

Alexandra Ocasio-Cortez (born in 1989) won a stunning victory in the Democratic Party primary election of June 26, 2018. Although outspent by a factor of 18 to 1 by her opponent (Democratic Caucus Chair, Joseph Crawley), she won the primary by 57% to 42%. Her campaign contributions came from small individual donors, while his came in large blocks, from corporations. Ocasio-Cortez calls for the United States to transition by 2035 to an electrical grid running on 100% renewable-energy production and end the use of fossil fuels. She calls healthcare "a human right", and says: "Almost every other developed nation in the world has universal healthcare. It's time the United States catch up to the rest of the world in ensuring all people have real healthcare coverage that doesn't break the bank".

The Guardian called her victory "one of the biggest upsets in recent American political

history", and Senator Bernie Sanders commented "She took on the entire local Democratic establishment in her district and won a very strong victory. She demonstrated once again what progressive grassroots politics can do". The lesson that the US Democratic Party must learn from this is that in order to overthrow Donald Trump's openly racist and climate-change-denying Republican Party, they must free themselves from the domination of corporate oligarchs, and instead stand for honest government and progressive values.

Even before taking her place in the US House of Representatives, with its newly-won Democratic majority, Alexandria Ocasio-Cortez became the leader of a campaign for a Green New Deal. This program takes its inspiration from the massive Federal government program by which Franklin Delano Roosevelt ended the depression of the 1930's. FDR's New Deal built dams, planted forests, and in general to create much needed infrastructure, while at the same time addressing the problem of unemployment by providing jobs. Wikipedia describes FDR's New Deal as follows:

"The New Deal was a series of programs, public work projects, financial reforms and regulations enacted by President Franklin D. Roosevelt in the United States between 1933 and 1936. It responded to needs for relief, reform and recovery from the Great Depression. Major federal programs included the Civilian Conservation Corps (CCC), the Civil Works Administration (CWA), the Farm Security Administration (FSA), the National Industrial Recovery Act of 1933 (NIRA) and the Social Security Administration (SSA). They provided support for farmers, the unemployed, youth and the elderly. The New Deal included new constraints and safeguards on the banking industry and efforts to re-inflate the economy after prices had fallen sharply. New Deal programs included both laws passed by Congress as well as presidential executive orders during the first term of the presidency of Franklin D. Roosevelt. The programs focused on what historians refer to as the '3 Rs': relief for the unemployed and poor, recovery of the economy back to normal levels and reform of the financial system to prevent a repeat depression."

Alexandria Ocasio-Cortez believes that the climate emergency that the world now faces is a much more severe emergency than the great depression. Indeed, if quick action is not taken immediately, the long-term effects of catastrophic climate change pose existential threats to human civilization and the biosphere. Therefore she advocates a massive governmental program to create renewable energy infrastructure. Such a program, like FDR's New Deal, would simultaneously solve the problem of unemployment. Money for the program could be taken from the Pentagon's obscenely bloated budget. Ocasio-Cortez has also proposed a 70% income tax for the ultra-wealthy.

According to a January 24 2019 article by Robert R. Raymond, "When polled, 92 percent of registered Democratic voters say they support the Green New Deal. But perhaps more importantly, a full 81 percent of all registered voters support it - a number that includes both Republicans and Democrats."[27]

[27]https://truthout.org/articles/the-democratic-party-is-further-to-the-right-than-most-voters/

Figure 3.33: **Alexandria Ocasio-Cortez. She was the youngest woman ever to be elected to the US House of Representatives.**

Figure 3.34: **The Green New Deal advocated by Ocasio-Cortez proposes to use jobs creating renewable energy infrastructure to ensure full employment, in a manner analogous to Roosevelt's New Deal.**

Figure 3.35: **Members of the Sunrise movement in the office of House Majority Leader Nancy Pelosi, protesting against her lack of support for the Green New Deal.**

Figure 3.36: **Award-winning author Naomi Klein, speaking at the Sanders Institute in January, 2019.**

Naomi Klein on the urgency of the Green New Deal

A recent article by journalist Naomi LaChance describes a meeting at the Sanders Institute (founded by Senator Bernie Sanders and his wife Jane) at which the famous author and activist Naomi Klein and others spoke about the scope and urgency of the Green New Deal. Here are some excerpts from the article:

Progressive journalist and activist Naomi Klein urged sweeping change that tackles the climate crisis, capitalism, racism and economic inequality in tandem on Friday in Burlington, Vt. If that seems challenging, add the fact that the clock is ticking[28] *and there might not be another chance.*

"We need to have started yesterday", *Klein said at the three-day Sanders Institute Gathering on a panel moderated by environmental activist Bill McKibben.* **"What all of us who follow the science know is that we just can't lose these four years",** *she said, referring to the presidency of climate change denier Donald Trump. The conference, organized by the think tank founded by Vermont Sen. Bernie Sanders' wife, Jane, is aimed*

[28] https://www.theguardian.com/environment/2018/oct/08/global-warming-must-not-exceed-15c-warns-landmark-un-report

at forming bold progressive agendas for the future.

Progressives are looking to incoming Democratic New York Rep. Alexandria Ocasio-Cortez for leadership as she galvanizes a grassroots effort by the youth-led climate change group Sunrise Movement[29] *to reduce fossil fuel dependence. Eighteen members of Congress support the idea of creating a House select committee to look at making a realistic plan by January 2020.*

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Chapter 4

REFUGEES FROM CLIMATE CHANGE

4.1 Climate change as genocide

Climate change does not affect all parts of the world equally. The harshest effects of the extreme weather that we are already experiencing are disproportionately felt by the poorest people of the world.

In March, 2017. the Security Council was informed [1] that 20 million people in four countries, Nigeria, Somalia, South Sudan and Yemen, were in danger of dying unless provided with immediate help. The cost of the necessary aid was estimated to be $4.4 billion. The developed world's response has been a shrug of indifference. By the midsummer. 2017 only a tenth of the amount needed had been raised.

Conflicts and famine are interlinked. The struggle for food produces conflicts; and famine is often used as an instrument of war. Food aid, when available, is often deliberately blocked or destroyed by warring factions. Boko Haram in Nigeria, al-Shabaab in Somalia, assorted militias and the government in South Sudan, and Saudi-backed forces in Yemen all interfered with the delivery of aid supplies.

In the future, the effects of rising temperatures and reduced rainfall will disproportionately affect poor farmers of Africa, the Middle East, South Asia, and Latin America. If the more affluent parts of the world continue to produce greenhouse gasses in a business-as-usual scenario, and if they continue to ignore calls for help from starving people, these actions will amount to genocide.

[1] by Stephen O'Brian, UN Under Secretary General for Humanitarian Affairs

Figure 4.1: **A starving child in Somalia.**

4.2 The United Nations High Commission on Refugees

In an article on *Climate Change and Disasters* the United Nations High Commission on Refugees makes the following statement:

"The Earth's climate is changing at a rate that has exceeded most scientific forecasts. Some families and communities have already started to suffer from disasters and the consequences of climate change, forced to leave their homes in search of a new beginning.

"For UNHCR, the consequences of climate change are enormous. Scarce natural resources such as drinking water are likely to become even more limited. Many crops and some livestock are unlikely to survive in certain locations if conditions become too hot and dry, or too cold and wet. Food security, already a concern, will become even more challenging.

"People try to adapt to this situation, but for many this will mean a conscious move to another place to survive. Such moves, or the effects of climate change on natural resources, may spark conflict with other communities, as an increasing number of people compete for a decreasing amount of resources.

"Since 2009, an estimated one person every second has been displaced by a disaster, with an average of 22.5 million people displaced by climate- or weather-related events since 2008 (IDMC 2015). Disasters and slow onsets, such as droughts in Somalia in 2011 and 2012, floods in Pakistan between 2010 and 2012, and the earthquake in Nepal in 2015, can leave huge numbers of people traumatized without shelter, clean water and basic supplies."

4.3 Populations displaced by sea level rise

In a recent article[2] discussed the long-term effects of sea level rise and the massive refugee crisis that it might create. By 2060, about 1.4 billion people could be climate change refugees, according to the paper, and that number could reach 2 billion by 2100.

The lead author, Prof. Emeritus Charles Geisler of Cornell University says: "The colliding forces of human fertility, submerging coastal zones, residential retreat, and impediments to inland resettlement is a huge problem. We offer preliminary estimates of the lands unlikely to support new waves of climate refugees due to the residues of war, exhausted natural resources, declining net primary productivity, desertification, urban sprawl, land concentration, 'paving the planet' with roads and greenhouse gas storage zones offsetting permafrost melt."

We should notice that Prof. Geisler's estimate of 2 billion climate refugees by 2100 includes all causes, not merely sea level rise. However, the number of refugees from sea level rise alone will be very large, since all the world's coastal cities, and many river deltas will be at risk.

4.4 Populations displaced by drought and famine

Climate change could produce a refugee crisis that is "unprecedented in human history", Barack Obama has warned as he stressed global warming was the most pressing issue of the age.

Speaking at an international food conference in Milan, the former US President said rising temperatures were already making it more difficult to grow crops and rising food prices were "leading to political instability".

If world leaders put aside "parochial interests" and took action to reduce greenhouse gas emissions by enough to restrict the rise to one or two degrees Celsius, then humanity would probably be able to cope.

Failing to do this, Mr Obama warned, increased the risk of "catastrophic" effects in the future, "not only real threats to food security, but also increases in conflict as a consequence of scarcity and greater refugee and migration patterns".

"If you think about monsoon patterns in the Indian subcontinent, maybe half a billion people rely on traditional rain patterns in those areas,"

4.5 Populations displaced by rising temperatures

A new study published in Nature: Climate Change has warned that up to 75% of the world's population could face deadly heat waves by 2100 unless greenhouse gas emissions are rapidly controlled.[3]. The following is an excerpt from the article:

[2]Geisler C. et al,, *Impediments to inland resettlement under conditions of accelerated sea level rise* , Land Use Policy, Vol **55**, July 2017, Pages 322-330

[3]Mora, C. et al., *Global risk of deadly heat*, Nature: Climate Change, 19 June 2017

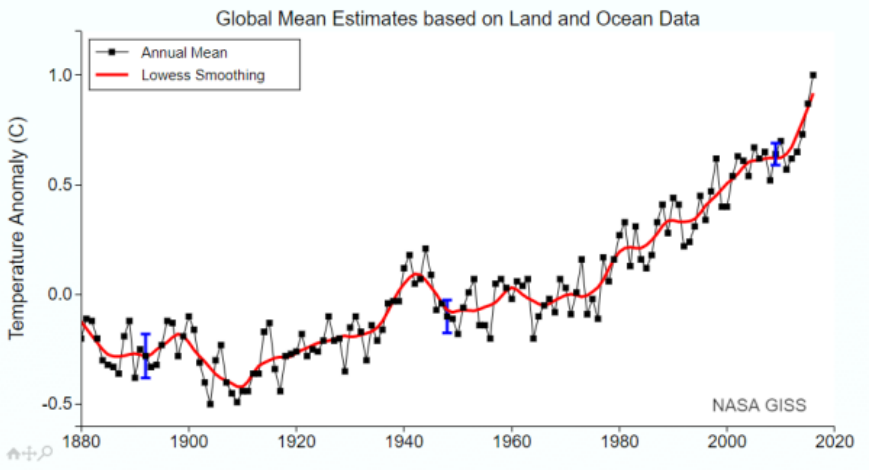

Figure 4.2: **This figure shows an alarming upward turn in the average global temperature**

"Here we conducted a global analysis of documented lethal heat events to identify the climatic conditions associated with human death and then quantified the current and projected occurrence of such deadly climatic conditions worldwide. We reviewed papers published between 1980 and 2014, and found 783 cases of excess human mortality associated with heat from 164 cities in 36 countries.

"Based on the climatic conditions of those lethal heat events, we identified a global threshold beyond which daily mean surface air temperature and relative humidity become deadly. Around 30% of the world's population is currently exposed to climatic conditions exceeding this deadly threshold for at least 20 days a year.

"By 2100, this percentage is projected to increase to 48% under a scenario with drastic reductions of greenhouse gas emissions and 74% under a scenario of growing emissions. An increasing threat to human life from excess heat now seems almost inevitable, but will be greatly aggravated if greenhouse gases are not considerably reduced." [4]

4.6 Populations displaced by war

A recent article in *The Guardian*[5] discusses the relationship between climate change and war, Here are some excerpts from the article:

"Climate change is set to cause a refugee crisis of 'unimaginable scale', according to senior military figures, who warn that global warming is the greatest security threat of the 21st century and that mass migration will become the 'new normal'.

[4]See also https://phys.org/news/2017-08-deadly-south-asia-century.html and https://cleantechnica.com/2017/09/28/extreme-heatwaves-like-recent-lucifer-heatwave-become-normal-europe-2050s/

[5]Thursday, 1 December, 2016

"The generals said the impacts of climate change were already factors in the conflicts driving a current crisis of migration into Europe, having been linked to the Arab Spring, the war in Syria and the Boko Haram terrorist insurgency.

"Military leaders have long warned that global warming could multiply and accelerate security threats around the world by provoking conflicts and migration. They are now warning that immediate action is required.

"'Climate change is the greatest security threat of the 21st century,' said Maj Gen Muniruzzaman.

"Muniruzzaman, chairman of the Global Military Advisory Council on climate change and a former military adviser to the president of Bangladesh. He said one meter of sea level rise will flood 20% of his nation. 'We're going to see refugee problems on an unimaginable scale, potentially above 30 million people.'

"Previously, Bangladesh's finance minister, Abul Maal Abdul Muhith, called on Britain and other wealthy countries to accept millions of displaced people.

"Brig Gen Stephen Cheney, a member of the US Department of State's foreign affairs policy board and CEO of the American Security Project, said: 'Climate change could lead to a humanitarian crisis of epic proportions. We're already seeing migration of large numbers of people around the world because of food scarcity, water insecurity and extreme weather, and this is set to become the new normal'.

4.7 Political reactions to migration

Brexit

Across the developed world, the reaction to threatened migration of refugees from climate change has been less than generous, to say the least. The recent decision of Britain to leave the European Union was motivated largely by the fear of British workers that EU laws would force their country to accept large numbers of refugees.

Swings to the right in Europe

In Germany, Angela Merkel's generous policies towards refugees have cost her votes, while an openly racist party, the Alternative for Germany (AfD) party, has gained in strength. Frauke Petry, 40, the party's leader, has said border guards might need to turn guns on anyone crossing a frontier illegally. The party's policy platform says "Islam does not belong in Germany" and calls for a ban on the construction of mosques.

In September, 2017, eight people from the neo-Nazi Freital Group were put on trial in Dresden for bomb attacks on homes for asylum applicants. Hundreds of similar assaults occur in Germany every year, but they had never before been tried as terrorism in a federal court.

In the German election, which took place on Sunday, October 1, 2017, Angela Merkel won a fourth term as Chancellor, but her party won only 33% of the votes, a percentage

much reduced from the 41% won in the election of 2013. Angela Merkel was paying a high price for her refugee-friendly policies.

Meanwhile the far right anti-immigration AfD party made a historic breakthrough, winning 13.5% of the vote, thus becoming the first overtly nationalist party to sit in the Bundestag in 60 years. The Greens have already complained that "Nazis have returned to parliament". In fact, members of the AfD party have begun to say that Germans should stop being ashamed of their country's Nazi past.

In France, the National Front is a nationalist party that uses populist rhetoric to promote its anti-immigration and anti-European Union positions. The party favors protectionist economic policies and would clamp down on government benefits for immigrants.

Similarly, in the Netherlands, the anti-European Union, anti-Islam Party for Freedom has called for closing all Islamic schools and recording the ethnicity of all Dutch citizens. In early November, the party was leading in polls ahead of next year's parliamentary elections.

Other far-right anti-immigrant parties in Europe include Golden Dawn (Greece), Jobbic (Hungary), Sweden Democrats (Sweden), Freedom Party (Austria), and People's Party - Our Slovakia (Slovakia). All of these parties have gained in strength because of the widespread fear of immigration.

Populism in the United States

The election of Donald Trump, who ran for President in 2016 on an openly racist and anti-immigrant platform, can also be seen as the result of fear of immigration, especially on the part of industrial workers.

4.8 A more humane response to the refugee crisis

In the long-term future, climate change will make the refugee crisis much more severe. Heat and drought will make large regions of the world uninhabitable, and will threaten many populations with famine. The severity of the refugee crisis will depend on how quickly we reduce greenhouse gas emissions.

While making many parts of the world uninhabitable, long-term climate change will make other regions more suitable for human habitation and agriculture. For example, farming will become more possible in Siberia, Greenland, the Canadian Arctic, Alaska and Patagonia. A humane response to the refugee crisis could include the generous opening of these regions to refuges.

The global population of humans is currently increasing by almost a billion people every decade. Global population must be stabilized, and in the long run, gradually reduced. Money currently wasted (or worse than wasted) on armaments could be used instead to promote universal primary health care, and with it, universal access to the knowledge and materials needed for family planning.

Finally, reduced consumption of meat, particularly beef, would shorten the food chain thus make more food available for famine relief.

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Chapter 5

THE THREAT OF LARGE-SCALE FAMINE

"Unless progress with agricultural yields remains very strong, the next century will experience human misery that, on a sheer numerical scale, will exceed everything that has come before"

Nobel Laureate Norman Borlaug speaking of a global food crisis in the 21st century

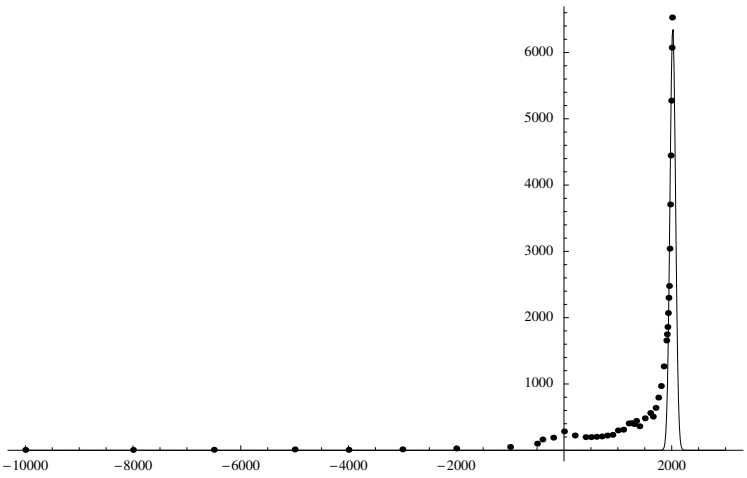

Figure 5.1: **Population growth and fossil fuel use, seen on a time-scale of several thousand years. The dots are population estimates in millions from the US Census Bureau. Fossil fuel use appears as a spike-like curve, rising from almost nothing to a high value, and then falling again to almost nothing in the space of a few centuries. When the two curves are plotted together, the explosive rise of global population is seen to be simultaneous with, and perhaps partially driven by, the rise of fossil fuel use. This raises the question of whether the world's population is headed for a crash when the fossil fuel era has ended.** (Author's own graph)

5.1 Introduction

As glaciers melt in the Himalayas, depriving India and China of summer water supplies; as sea levels rise, drowning the fertile rice fields of Viet Nam and Bangladesh; as drought threatens the productivity of grain-producing regions of North America; and as the end of the fossil fuel era impacts modern high-yield agriculture, there is a threat of wide-spread famine. There is a danger that the 1.5 billion people who are undernourished today will not survive an even more food-scarce future.

People threatened with famine will become refugees, desperately seeking entry into countries where food shortages are less acute. Wars, such as those currently waged in the Middle East, will add to the problem.

What can we do to avoid this crisis, or at least to reduce its severity? We must urgently address the problem of climate change; and we must shift money from military expenditure to the support of birth control programs and agricultural research. We must also replace the institution of war by a system of effective global governance and enforcible international laws.

5.2 Optimum population in the distant future

What is the optimum population of the world? It is certainly not the maximum number that can be squeezed onto the globe by eradicating every species of plant and animal that cannot be eaten. The optimum global population is one that can be supported in comfort, equality and dignity - and with respect for the environment.

In 1848 (when there were just over one billion people in the world), John Stuart Mill described the optimal global population in the following words:

"The density of population necessary to enable mankind to obtain, in the greatest degree, all the advantages of cooperation and social intercourse, has, in the most populous countries, been attained. A population may be too crowded, although all be amply supplied with food and raiment."

"... Nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings; every flowery waste or natural pasture plowed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture. If the earth must lose that great portion of its pleasantness which it owes to things that the unlimited increase of wealth and population would extirpate from it, for the mere purpose of enabling it to support a larger, but not better or happier population, I sincerely hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it."[1]

Has the number of humans in the world already exceeded the earth's sustainable limits? Will the global population of humans crash catastrophically after having exceeded the carrying capacity of the environment? There is certainly a danger that this will happen - a danger that the 21st century will bring very large scale famines to vulnerable parts of the world, because modern energy-intensive agriculture will be dealt a severe blow by prohibitively high petroleum prices, and because climate change will reduce the world's agricultural output. When the major glaciers in the Himalayas have melted, they will no longer be able to give India and China summer water supplies; rising oceans will drown much agricultural land; and aridity will reduce the output of many regions that now produce much of the world's grain. Falling water tables in overdrawn aquifers, and loss of topsoil will add to the problem. We should be aware of the threat of a serious global food crisis in the 21st century if we are to have a chance of avoiding it.

The term *ecological footprint* was introduced by William Rees and Mathis Wackernagel in the early 1990's to compare demands on the environment with the earth's capacity to regenerate. In 2005, humanity used environmental resources at such a rate that it would take 1.3 earths to renew them. In other words, we have already exceeded the earth's carrying capacity. Since eliminating the poverty that characterizes much of the world

[1] John Stuart Mill, *Principles of Political Economy, With Some of Their Applications to Social Philosophy*, (1848).

today will require more resources per capita, rather than less. it seems likely that in the era beyond fossil fuels, the optimum global population will be considerably less than the present population of the world.

5.3 Population growth and the Green Revolution

In 1944 the Norwegian-American plant geneticist Norman Borlaug was sent to Mexico by the Rockefeller Foundation to try to produce new wheat varieties that might increase Mexico's agricultural output. Borlaug's dedicated work on this project was spectacularly successful. He remained with the project for 16 years, and his group made 6,000 individual crossings of wheat varieties to produce high-yield disease-resistant strains.

In 1963, Borlaug visited India, bringing with him 100 kg. of seeds from each of his most promising wheat strains. After testing these strains in Asia, he imported 450 tons of the Lerma Rojo and Sonora 64 varieties - 250 tons for Pakistan and 200 for India. By 1968, the success of these varieties was so great that school buildings had to be commandeered to store the output. Borlaug's work began to be called a "Green Revolution". In India, the research on high-yield crops was continued and expanded by Prof. M.S. Swaminathan and his coworkers. The work of Green Revolution scientists, such Norman Borlaug and M.S. Swaminathan, has been credited with saving the lives of as many as a billion people.

Despite these successes, Borlaug believes that the problem of population growth is still a serious one. "Africa and the former Soviet republics", Borlaug states, "and the Cerrado[2], are the last frontiers. After they are in use, the world will have no additional sizable blocks of arable land left to put into production, unless you are willing to level whole forests, which you should not do. So, future food-production increases will have to come from higher yields. And though I have no doubt that yields will keep going up, whether they can go up enough to feed the population monster is another matter. Unless progress with agricultural yields remains very strong, the next century will experience human misery that, on a sheer numerical scale, will exceed the worst of everything that has come before."

A very serious problem with Green Revolution plant varieties is that they require heavy inputs of pesticides, fertilizers and irrigation. Because of this, the use of high-yield varieties contributes to social inequality, since only rich farmers can afford the necessary inputs. Monocultures, such as the Green Revolution varieties may also prove to be vulnerable to future epidemics of plant diseases, such as the epidemic that caused the Irish Potato Famine in 1845. Even more importantly, pesticides, fertilizers and irrigation all depend on the use of fossil fuels. One must therefore ask whether high agricultural yields can be maintained in the future, when fossil fuels are expected to become prohibitively scarce and expensive.

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[2] The Cerrado is a large savanna region of Brazil.

Figure 5.2: **Norman Borlaug's work on developing high-yield disease-resistant plant varieties won him a Nobel Peace Prize in 1970.**

to store the output. Borlaug's work began to be called a "Green Revolution". In India, the research on high-yield crops was continued and expanded by Prof. M.S. Swaminathan and his coworkers. The work of Green Revolution scientists, such Norman Borlaug and M.S. Swaminathan, has been credited with saving the lives of as many as a billion people.

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With regard to the prospect of increasing the area of cropland, a report by the United Nations Food and Agricultural Organization (*Provisional Indicative World Plan for Agricultural Development*, FAO, Rome, 1970) states that "In Southern Asia,... in some countries of Eastern Asia, in the Near East and North Africa... there is almost no scope for expanding agricultural area... In the drier regions, it will even be necessary to return to permanent pasture the land that is marginal and submarginal for cultivation. In most of Latin America and Africa south of the Sahara, there are still considerable possibilities for expanding cultivated areas; but the costs of development are high, and it will often be more

[3] The Cerrado is a large savanna region of Brazil.

Figure 5.3: **Professor M.S. Swaminathan, father of the Green Revolution in India.** (Open and Shut7)

Figure 5.4: **Norman Borlaug and agronomist George Harrer in 1943.** (Human Wrongs Watch)

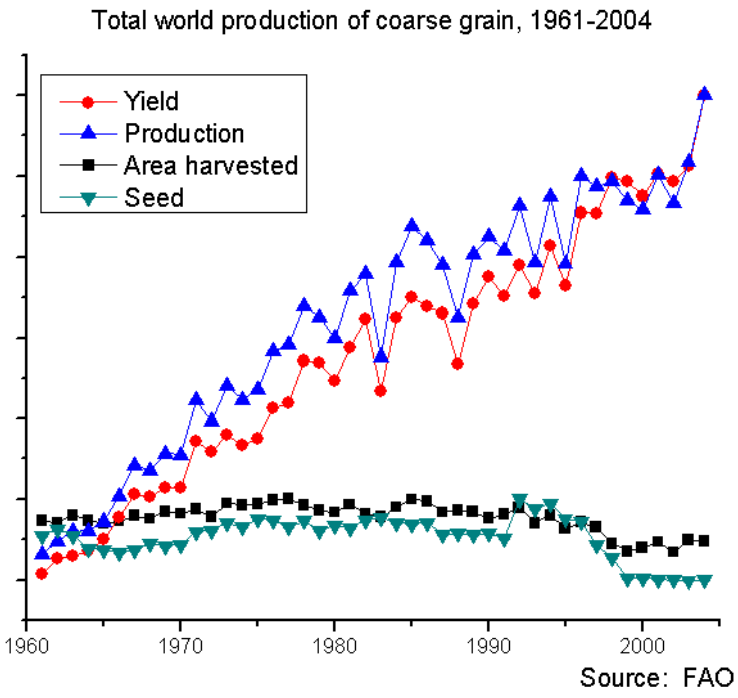

Figure 5.5: **This graph shows the total world production of coarse grain between 1960 and 2004. Because of high-yield varieties, the yield of grain increased greatly. Notice, however, that the land under cultivation remained almost constant. High-yield agriculture depends on large inputs of fossil fuel energy and irrigation, and may be difficult to maintain in the future.** (FAO)

economical to intensify the utilization of areas already settled." Thus there is a possibility of increasing the area of cropland in Africa south of the Sahara and in Latin America, but only at the cost of heavy investment and at the additional cost of destruction of tropical rain forests.

Rather than an increase in the global area of cropland, we may encounter a future loss of cropland through soil erosion, salination, desertification, loss of topsoil, depletion of minerals in topsoil, urbanization and failure of water supplies. In China and in the southwestern part of the United States, water tables are falling at an alarming rate. The Ogallala aquifer (which supplies water to many of the plains states in the central and southern parts of the United States) has a yearly overdraft of 160%.

In the 1950's, both the U.S.S.R and Turkey attempted to convert arid grasslands into wheat farms. In both cases, the attempts were defeated by drought and wind erosion, just as the wheat farms of Oklahoma were overcome by drought and dust in the 1930's.

If irrigation of arid lands is not performed with care, salt may be deposited, so that the land is ruined for agriculture. This type of desertification can be seen, for example, in some parts of Pakistan. Another type of desertification can be seen in the Sahel region of Africa, south of the Sahara. Rapid population growth in the Sahel has led to overgrazing, destruction of trees, and wind erosion, so that the land has become unable to support even its original population.

Especially worrying is a prediction of the International Panel on Climate Change concerning the effect of global warming on the availability of water: According to Model A1 of the IPCC, global warming may, by the 2050's, have reduced by as much as 30% the water available in large areas of world that now a large producers of grain[4].

Added to the agricultural and environmental problems, are problems of finance and distribution. Famines can occur even when grain is available somewhere in the world, because those who are threatened with starvation may not be able to pay for the grain, or for its transportation. The economic laws of supply and demand are not able to solve this type of problem. One says that there is no "demand" for the food (meaning demand in the economic sense), even though people are in fact starving.

5.4 Energy-dependence of modern agriculture

Food prices and energy prices

A very serious problem with Green Revolution plant varieties is that they require heavy inputs of pesticides, fertilizers and irrigation. Because of this, the use of high-yield varieties contributes to social inequality, since only rich farmers can afford the necessary inputs. Monocultures, such as the Green Revolution varieties may also prove to be vulnerable to future epidemics of plant diseases, such as the epidemic that caused the Irish Potato Famine in 1845. Even more importantly, pesticides, fertilizers and irrigation all depend on the use of fossil fuels. One must therefore ask whether high agricultural yields can be

[4]See the discussion of the Stern Report in Chapter 7.

maintained in the future, when fossil fuels are expected to become prohibitively scarce and expensive.

Modern agriculture has become highly dependent on fossil fuels, especially on petroleum and natural gas. This is especially true of production of the high-yield grain varieties introduced in the Green Revolution, since these require especially large inputs of fertilizers, pesticides and irrigation. Today, fertilizers are produced using oil and natural gas, while pesticides are synthesized from petroleum feedstocks, and irrigation is driven by fossil fuel energy. Thus agriculture in the developed countries has become a process where inputs of fossil fuel energy are converted into food calories. If one focuses only on the farming operations, the fossil fuel energy inputs are distributed as follows:

1. Manufacture of inorganic fertilizer, 31%
2. Operation of field machinery, 19%
3. Transportation, 16%
4. Irrigation, 13%
5. Raising livestock (not including livestock feed), 8%
6. Crop drying, 5%
7. Pesticide production, 5%
8. Miscellaneous, 8%

The ratio of the fossil fuel energy inputs to the food calorie outputs depends on how many energy-using elements of food production are included in the accounting. David Pimental and Mario Giampietro of Cornell University estimated in 1994 that U.S. agriculture required 0.7 kcal of fossil fuel energy inputs to produce 1.0 kcal of food energy. However, this figure was based on U.N. statistics that did not include fertilizer feedstocks, pesticide feedstocks, energy and machinery for drying crops, or electricity, construction and maintenance of farm buildings. A more accurate calculation, including these inputs, gives an input/output ratio of approximately 1.0. Finally, if the energy expended on transportation, packaging and retailing of food is included, Pimental and Giampietro found that the input/output ratio for the U.S. food system was approximately 10, and this figure did not include energy used for cooking.

The Brundtland Report's [5] estimate of the global potential for food production assumes "that the area under food production can be around 1.5 billion hectares (3.7 billion acres - close to the present level), and that the average yields could go up to 5 tons of grain equivalent per hectare (as against the present average of 2 tons of grain equivalent)." In

[5] World Commission on Environment and Development, *Our Common Future*, Oxford University Press, (1987). This book is often called "The Brundtland Report" after Gro Harlem Brundtland, the head of WCED, who was then Prime Minister of Norway.

other words, the Brundtland Report assumes an increase in yields by a factor of 2.5. This would perhaps be possible if traditional agriculture could everywhere be replaced by energy-intensive modern agriculture using Green Revolution plant varieties. However, Pimental and Giampietro's studies show that modern energy-intensive agricultural techniques cannot be maintained after fossil fuels have been exhausted.

At the time when the Brundtland Report was written (1987), the global average of 2 tons of grain equivalent per hectare included much higher yields from the sector using modern agricultural methods. Since energy-intensive petroleum-based agriculture cannot be continued in the post-fossil-fuel era, future average crop yields will probably be much less than 2 tons of grain equivalent per hectare.

The 1987 global population was approximately 5 billion. This population was supported by 3 billion tons of grain equivalent per year. After fossil fuels have been exhausted, the total world agricultural output is likely to be considerably less than that, and therefore the population that it will be possible to support will probably be considerably less than 5 billion, assuming that our average daily per capita use of food calories remains the same, and assuming that the amount of cropland and pasturage remains the same (1.5 billion hectares cropland, 3.0 billion hectares pasturage).

The Brundtland Report points out that "The present (1987) global average consumption of plant energy for food, seed and animal feed amounts to 6,000 calories daily, with a range among countries of 3,000-15,000 calories, depending on the level of meat consumption." Thus there is a certain flexibility in the global population that can survive on a given total agricultural output. If the rich countries were willing to eat less meat, more people could be supported.

5.5 Effects of climate change on agriculture

Effects of temperature increase on crops

There is a danger that when climate change causes both temperature increases and increased aridity in regions like the US grain belt, yields will be very much lowered. Of the three main grain types (corn, wheat and rice) corn is the most vulnerable to the direct effect of increases in temperature. One reason for this is the mechanism of pollination of corn: A pollen grain lands on one end of a corn-silk strand, and the germ cell must travel the length of the strand in order to fertilize the kernel. At high temperatures, the corn silk becomes dried out and withered, and is unable to fulfill its biological function. Furthermore, heat can cause the pores on the underside of the corn leaf to close, so that photosynthesis stops.

According to a study made by Mohan Wali and coworkers at Ohio State University, the photosynthetic activity of corn increases until the temperature reaches 20 degrees Celsius. It then remains constant until the temperature reaches 35 degrees, after which it declines. At 40 degrees and above, photosynthesis stops altogether.

Scientists in the Philippines report that the pollination of rice fails entirely at 40 degrees

Celsius, leading to crop failures. Wheat yields are also markedly reduced by temperatures in this range.

Predicted effects on rainfall

According to the Stern Report, some of the major grain-producing areas of the world might loose up to 30% of their rainfall by 2050. These regions include much of the United States, Brazil, the Mediterranean region, Eastern Russia and Belarus, the Middle East, Southern Africa and Australia. Of course possibilities for agriculture may simultaneously increase in other regions, but the net effect of climate change on the world's food supply is predicted to be markedly negative.

Unsustainable use of groundwater

It may seem surprising that fresh water can be regarded as a non-renewable resource. However, groundwater in deep aquifers is often renewed very slowly. Sometimes renewal requires several thousand years. When the rate of withdrawal of groundwater exceeds the rate of renewal, the carrying capacity of the resource has been exceeded, and withdrawal of water becomes analogous to mining a mineral. However, it is more serious than ordinary mining because water is such a necessary support for life.

In many regions of the world today, groundwater is being withdrawn faster than it can be replenished, and important aquifers are being depleted. In China, for example, groundwater levels are falling at an alarming rate. Considerations of water supply in relation to population form the background for China's stringent population policy.

At a recent lecture, Lester Brown of the Worldwatch Institute was asked by a member of the audience to name the resource for which shortages would most quickly become acute. Most of the audience expected him to name oil, but instead he replied "water". Lester Brown then cited China's falling water table. He predicted that within decades, China would be unable to feed itself. He said that this would not cause hunger in China itself: Because of the strength of China's economy, the country would be able to purchase grain on the world market. However Chinese purchases of grain would raise the price, and put world grain out of reach of poor countries in Africa. Thus water shortages in China will produce famine in parts of Africa, Brown predicted.

Under many desert areas of the world are deeply buried water tables formed during glacial periods when the climate of these regions was wetter. These regions include the Middle East and large parts of Africa. Water can be withdrawn from such ancient reservoirs by deep wells and pumping, but only for a limited amount of time.

In oil-rich Saudi Arabia, petroenergy is used to drill wells for ancient water and to bring it to the surface. Much of this water is used to irrigate wheat fields, and this is done to such an extent that Saudi Arabia exports wheat. The country is, in effect, exporting its ancient heritage of water, a policy that it may, in time, regret. A similarly short-sighted project is Muammar Qaddafi's enormous pipeline, which will bring water from ancient sub-desert reservoirs to coastal cities of Libya.

Figure 5.6: **Whitechuck Glacier in the North Cascades National Park in 1973.** (Nicholas College)

Figure 5.7: **The same glacier in 2006** (Nicholas College)

In the United States, the great Ogallala aquifer is being overdrawn. This aquifer is an enormous stratum of water-saturated sand and gravel underlying parts of northern Texas, Oklahoma, New Mexico, Kansas, Colorado, Nebraska, Wyoming and South Dakota. The average thickness of the aquifer is about 70 meters. The rate of water withdrawal from the aquifer exceeds the rate of recharge by a factor of eight.

Thus we can see that in many regions, the earth's present population is living on its inheritance of water, rather than its income. This fact, coupled with rapidly increasing populations and climate change, may contribute to a food crisis partway through the 21st century.

Glacial melting and summer water supplies

The summer water supplies of both China and India are threatened by the melting of glaciers. The Gangotri glacier, which is the principle glacier feeding India's great Ganges River, is reported to be melting at an accelerating rate, and it could disappear within a few decades. If this happens,the Ganges could become seasonal, flowing only during the monsoon season.

Chinese agriculture is also threatened by disappearing Himalayan glaciers, in this case those on the Tibet-Quinghai Plateau. The respected Chinese glaciologist Yao Tandong estimates that the glaciers feeding the Yangtze and Yellow Rivers are disappearing at the rate of 7% per year.

The Indus and Mekong Rivers will be similarly affected by the melting of glaciers. Lack of water during the summer season could have a serious impact on the irrigation of rice and wheat fields.

Forest loss and climate change

Mature forests contain vast amounts of sequestered carbon, not only in their trees, but also in the carbon-rich soil of the forest floor. When a forest is logged or burned to make way for agriculture, this carbon is released into the atmosphere. One fifth of the global carbon emissions are at present due to destruction of forests. This amount is greater than the CO_2 emissions for the world's transportation systems.

An intact forest pumps water back into the atmosphere, increasing inland rainfall and benefiting agriculture. By contrast, deforestation, for example in the Amazonian rainforest, accelerates the flow of water back into the ocean, thus reducing inland rainfall. There is a danger that the Amazonian rainforest may be destroyed to such an extent that the region will become much more dry. If this happens, the forest may become vulnerable to fires produced by lightning strikes. This is one of the feedback loops against which the Stern Report warns - the drying and burning of the Amazonian rainforest may become irreversible, greatly accelerating climate change, if destruction of the forest proceeds beyond a certain point.

Erosion of topsoil

Besides depending on an adequate supply of water, food production also depends on the condition of the thin layer of topsoil that covers the world's croplands. This topsoil is being degraded and eroded at an alarming rate: According to the World Resources Institute and the United Nations Environment Programme, "It is estimated that since World War II, 1.2 billion hectares... has suffered at least moderate degradation as a result of human activity. This is a vast area, roughly the size of China and India combined." This area is 27% of the total area currently devoted to agriculture [6]. The report goes on to say that

[6]The total area devoted to agriculture throughout the world is 1.5 billion hectares of cropland and 3.0 billion hectares of pasturage.

the degradation is greatest in Africa.

The risk of topsoil erosion is greatest when marginal land is brought into cultivation, since marginal land is usually on steep hillsides which are vulnerable to water erosion when wild vegetation is removed.

David Pimental and his associates at Cornell University pointed out in 1995 that "Because of erosion-associated loss of productivity and population growth, the per capita food supply has been reduced over the past 10 years and continues to fall. The Food and Agricultural Organization reports that the per capita production of grains which make up 80% of the world's food supply, has been declining since 1984."

Pimental et al. add that "Not only is the availability of cropland per capita decreasing as the world population grows, but arable land is being lost due to excessive pressure on the environment. For instance, during the past 40 years nearly one-third of the world's cropland (1.5 billion hectares) has been abandoned because of soil erosion and degradation. Most of the replacement has come from marginal land made available by removing forests. Agriculture accounts for 80% of the annual deforestation."

Topsoil can also be degraded by the accumulation of salt when irrigation water evaporates. The worldwide area of irrigated land has increased from 8 million hectares in 1800 to more than 100 million hectares today. This land is especially important to the world food supply because it is carefully tended and yields are large in proportion to the area. To protect this land from salination, it should be irrigated in such a way that evaporation is minimized.

Finally cropland with valuable topsoil is being be lost to urban growth and highway development, a problem that is made more severe by growing populations and by economic growth.

Laterization

Every year, more than 100,000 square kilometers of rain forest are cleared and burned, an area which corresponds to that of Switzerland and the Netherlands combined. Almost half of the world's tropical forests have already been destroyed. Ironically, the land thus cleared often becomes unsuitable for agriculture within a few years.

Tropical soils may seem to be fertile when covered with luxuriant vegetation, but they are usually very poor in nutrients because of leeching by heavy rains. The nutrients which remain are contained in the vegetation itself; and when the forest cover is cut and burned, the nutrients are rapidly lost.

Often the remaining soil is rich in aluminum oxide and iron oxide. When such soils are exposed to oxygen and sun-baking, a rocklike substance called Laterite is formed. The temples of Angkor Wat in Cambodia are built of Laterite; and it is thought that laterization of the soil contributed to the disappearance of the Khmer civilization, which built these temples.

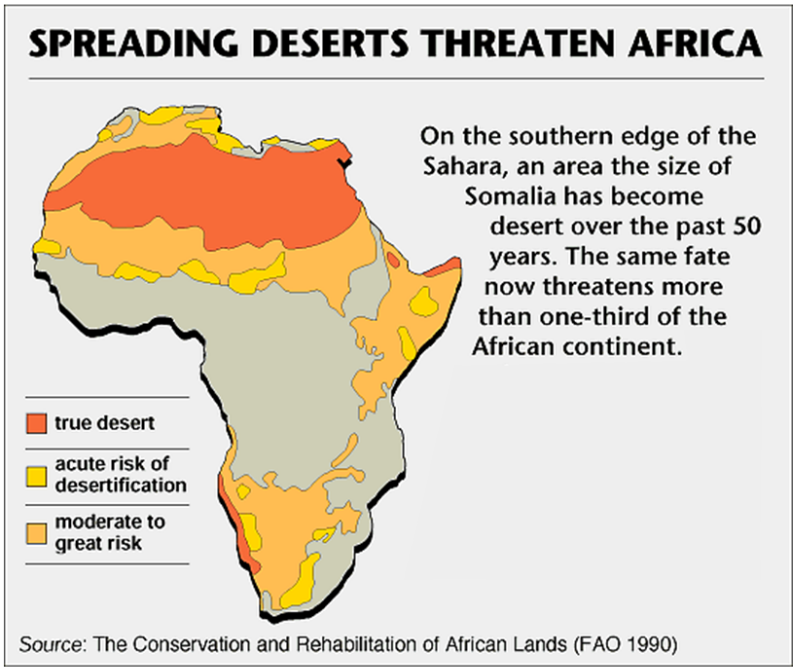

Figure 5.8: **Desert regions of the Africa that are in danger of spreading.** (FAO)

5.6 Harmful effects of industrialized farming

A major global public health crisis may soon be produced by the wholesale use of antibiotics in the food of healthy farm animals. The resistance factors produced by shovelling antibiotics into animal food produces resistance factors (plasmids) which can easily be transferred to human pathogens. A related problem is the excessive use of pesticides and artificial fossil-fuel-derived fertilizers in agriculture. Pharming is not a joke. It is a serious threat.[7]

Plasmids

Bacteria belong to a class of organisms (prokaryotes) whose cells do not have a nucleus. Instead, the DNA of the bacterial chromosome is arranged in a large loop. In the early

[7]http://ecowatch.com/2014/03/06/misuse-antibiotics-fatal-superbug-crisis/
http://ecowatch.com/2013/12/06/8-scary-facts-about-antibiotic-resistance/
http://ecowatch.com/2015/03/27/obama-fight-superbug-crisis/
http://ecowatch.com/2014/03/12/fda-regulation-antibiotics-factory-farms/
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http://www.bbc.com/news/health-34857015
http://sustainableagriculture.net/about-us/
https://pwccc.wordpress.com/programa/

1950's, Joshua Lederberg discovered that bacteria can exchange genetic information. He found that a frequently-exchanged gene, the F-factor (which conferred fertility), was not linked to other bacterial genes; and he deduced that the DNA of the F-factor was not physically a part of the main bacterial chromosome. In 1952, Lederberg coined the word "plasmid" to denote any extrachromosomal genetic system.

In 1959, it was discovered in Japan that genes for resistance to antibiotics can be exchanged between bacteria; and the name "R-factors" was given to these genes. Like the F-factors, the R-factors did not seem to be part of the main loop of bacterial DNA.

Because of the medical implications of this discovery, much attention was focused on the R-factors. It was found that they were plasmids, small loops of DNA existing inside the bacterial cell, but not attached to the bacterial chromosome. Further study showed that, in general, between one percent and three percent of bacterial genetic information is carried by plasmids, which can be exchanged freely even between different species of bacteria.

In the words of the microbiologist, Richard Novick, "Appreciation of the role of plasmids has produced a rather dramatic shift in biologists' thinking about genetics. The traditional view was that the genetic makeup of a species was about the same from one cell to another, and was constant over long periods of time. Now a significant proportion of genetic traits are known to be variable (present in some individual cells or strains, absent in others), labile (subject to frequent loss or gain) and mobile, all because those traits are associated with plasmids or other atypical genetic systems."

Because of the ease with which plasmids conferring resistance to antibiotics can be transferred from animal bacteria to the bacteria carrying human disease, the practice of feeding antibiotics to healthy farm animals is becoming a major human health hazard. The World Health Organization has warned that if we lose effective antibiotics through this mechanism, "Many common infections will no longer have a cure, and could kill unabated". The US Center for Disease Control has pointed to the emergence of "nightmare bacteria", and the chief medical officer for England Prof Dame Sally Davies has evoked parallels with the "apocalypse".

Pesticides, artificial fertilizers and topsoil

A closely analogous danger results from the overuse of pesticides and petroleum-derived fertilizers in agriculture. A very serious problem with Green Revolution plant varieties is that they require heavy inputs of pesticides, fertilizers and irrigation. Because of this, the use of high-yield varieties contributes to social inequality, since only rich farmers can afford the necessary inputs. Monocultures, such as the Green Revolution varieties may also prove to be vulnerable to future plant diseases, such as the epidemic that caused the Irish Potato Famine in 1845. Even more importantly, pesticides, fertilizers and irrigation all depend on the use of fossil fuels. One must ask, therefore, whether high-yield agriculture can be maintained in the post-fossil-fuel era.

Topsoil is degraded by excessive use of pesticides and artificial fertilizers. Natural topsoil is rich in organic material, which contains sequestered carbon that would otherwise

be present in our atmosphere in the form of greenhouse gases. In addition, natural topsoil contains an extraordinarily rich diversity of bacteria and worms that act to convert agricultural wastes from one year's harvest into nutrients for the growth of next year's crop. Pesticides kill these vital organisms, and make the use of artificial fertilizers necessary.

Finally, many small individual farmers, whose methods are sustainable, are being eliminated by secret land-grabs or put out of business because they cannot compete with unsustainable high-yield agriculture. Traditional agriculture contains a wealth of knowledge and biodiversity, which it would be wise for the world to preserve.

5.7 The demographic transition

The phrase "developing countries" is more than a euphemism; it expresses the hope that with the help of a transfer of technology from the industrialized nations, all parts of the world can achieve prosperity. Some of the forces that block this hope have just been mentioned. Another factor that prevents the achievement of worldwide prosperity is population growth.

In the words of Dr. Halfdan Mahler, former Director General of the World Health Organization, "Country after country has seen painfully achieved increases in total output, food production, health and educational facilities and employment opportunities reduced or nullified by excessive population growth."

The growth of population is linked to excessive urbanization, infrastructure failures and unemployment. In rural districts in the developing countries, family farms are often divided among a growing number of heirs until they can no longer be subdivided. Those family members who are no longer needed on the land have no alternative except migration to overcrowded cities, where the infrastructure is unable to cope so many new arrivals. Often the new migrants are forced to live in excrement-filled makeshift slums, where dysentery, hepatitis and typhoid are endemic, and where the conditions for human life sink to the lowest imaginable level. In Brazil, such shanty towns are called "favelas".

If modern farming methods are introduced in rural areas while population growth continues, the exodus to cities is aggravated, since modern techniques are less labor-intensive and favor large farms. In cities, the development of adequate infrastructure requires time, and it becomes a hopeless task if populations are growing rapidly. Thus, population stabilization is a necessary first step for development.

It can be observed that birth rates fall as countries develop. However, development is sometimes blocked by the same high birth rates that economic progress might have prevented. In this situation (known as the "demographic trap"), economic gains disappear immediately because of the demands of an exploding population.

For countries caught in the demographic trap, government birth control programs are especially important, because one cannot rely on improved social conditions to slow birth rates. Since health and lowered birth rates should be linked, it is appropriate that family-planning should be an important part of programs for public health and economic development.

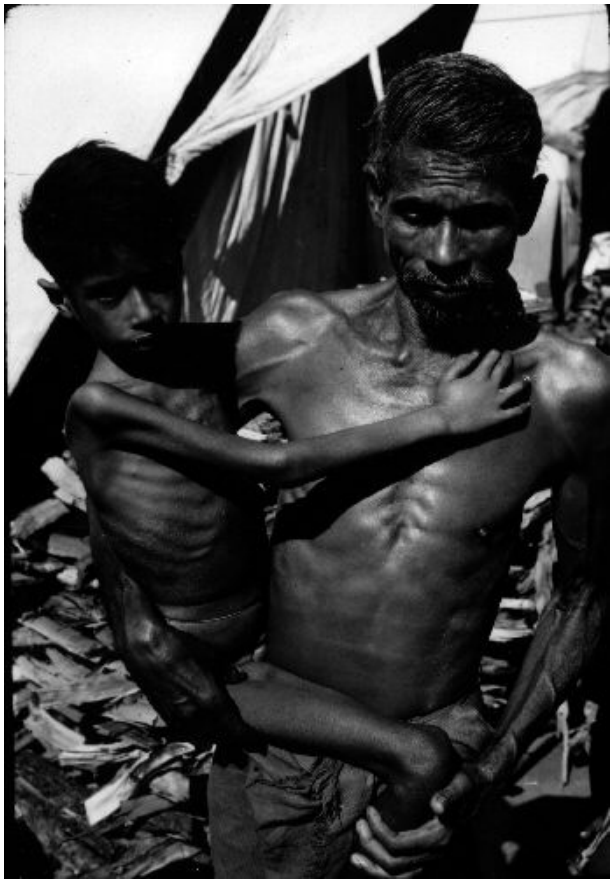

Figure 5.9: **Child suffering with the deficiency disease Marasmus in India.** (Public domain)

A recent study conducted by Robert F. Lapham of Demographic Health Surveys and W. Parker Maudlin of the Rockefeller Foundation has shown that the use of birth control is correlated both with socio-economic setting and with the existence of strong family-planning programs. The implication of this study is that even in the absence of increased living standards, family-planning programs can be successful, provided they have strong government support.

China, the world's most populous nation, has adopted the somewhat draconian policy of allowing only one child for families in living in towns and cities (35.9% of the population). Chinese leaders obtained popular support for their one-child policy by means of an educational program which emphasized future projections of diminishing water resources and diminishing cropland per person if population increased unchecked. Like other developing countries, China has a very young population, which will continue to grow even when fertility has fallen below the replacement level because so many of its members are contributing to the birth rate rather than to the death rate. China's present population is 1.3 billion. Its projected population for the year 2025 is 1.5 billion. China's one-child policy is supported by 75% of the country's people, but the methods of enforcement are sometimes criticized, and it has led to a M/F sex ratio of 1.17/1.00. The natural baseline for the sex ratio ranges between 1.03/1.00 and 1.07/1.00.

Education of women and higher status for women are vitally important measures, not only for their own sake, but also because in many countries these social reforms have proved to be the key to lower birth rates. Religious leaders who oppose programs for the education of women and for family planning on "ethical" grounds should think carefully about the scope and consequences of the catastrophic global famine which will undoubtedly occur within the next 50 years if population is allowed to increase unchecked. Do these leaders really wish to be responsible for the suffering and death from starvation of hundreds of millions of people?

At the United Nations Conference on Population and Development, held in Cairo in September, 1994, a theme which emerged very clearly was that one of the most important keys to controlling the global population explosion is giving women better education and equal rights. These goals are desirable for the sake of increased human happiness, and for the sake of the uniquely life-oriented point of view which women can give us; but in addition, education and improved status for women have shown themselves to be closely connected with lowered birth rates. When women lack education and independent careers outside the home, they can be forced into the role of baby-producing machines by men who do not share in the drudgery of cooking, washing and cleaning; but when women have educational, legal, economic, social and political equality with men, experience has shown that they choose to limit their families to a moderate size.

Sir Partha Dasgupta of Cambridge University has pointed out that the changes needed to break the cycle of overpopulation and poverty are all desirable in themselves. Besides education and higher status for women, they include state-provided social security for old people, provision of water supplies near to dwellings, provision of health services to all, abolition of child labor and general economic development.

Figure 5.10: **Education of women and higher status for women are vitally important measures, not only for their own sake, but also because these social reforms have proved to be the key to lower birth rates.** (Kundan Srivastava)

The UN Summit on Addressing Large Movements of Refugees and Migrants

On September 19, 2016, the United Nations General Assembly held a 1-day summit meeting to address the pressing problem of refugees. It is a problem that has been made acute by armed conflicts in the Middle East and Africa, and by climate change.

One of the outcomes of the summit was the a Declaration for Refugees and Migrants. Here is a statement of the severity of the problem from paragraph 3 of the Declaration:

"We are witnessing in today's world an unprecedented level of human mobility. More people than ever before live in a country other than the one in which they were born. Migrants are present in all countries of the world. Most of them move without incident. In 2015, their number surpassed 244 million, growing at a rate faster than the world's population. However, there are 65 million forcibly displaced persons, including over 21 million refugees, 3 million asylum seekers and over 40 million internally displaced persons."

Sadly, the world's response to the tragic plight of refugees fleeing from zones of armed conflict has been less than generous. Men, women and many children, trying to escape from almost certain death in the war-torn Middle East, have been met, not with sympathy and kindness, but with barbed wire and tear gas.

Germany's Chancellor, Angela Merkel, courageously made arrangements for her country to accept a large number of refugees, but as a consequence her party has suffered political setbacks. On the whole, European governments have moved to the right, as anti-refugee parties gained strength. The United States, Canada Australia and Russia, countries that could potentially save the lives of many refugees, have accepted almost none. In contrast, tiny Lebanon, despite all its problems, has become the home of so many refugees that they

are a very large fraction of the country's total population.

As the effects of climate change become more pronounced, we can expect the suffering and hopelessness of refugees to become even more severe. This is a challenge which the world must meet with humanity and solidarity.

The World Cities Report, 2016

According to the World Cities Report[8], by 2030, two thirds of the world's population will be living in cities. As the urban population increases, the land area occupied by cities is increasing at a higher rate. It is projected that by 2030, the urban population of developing countries will double, while the area covered by cites could triple.

Commenting on this, the UN-Habitat Executive Director, Joan Clos, said: "In the twenty years since the Habitat II conference, the world has seen a gathering of its population in urban areas. This has been accompanied by socioeconomic growth in many instances. But the urban landscape is changing and with it, the pressing need for a cohesive and realistic approach to urbanization".

"Such urban expansion is wasteful in terms of land and energy consumption and increases greenhouse gas emissions. The urban centre of gravity, at least for megacities, has shifted to the developing regions."

One can foresee that in the future, as fossil fuels become increasingly scarce, the problem of feeding urban populations will become acute.

5.8 Lester Brown's lecture in Copenhagen

After a lecture at the University of Copenhagen in the 1980's, Lester R. Brown of the Earth Policy Institute was asked which resource would be the first to become critically scarce. Everyone in the audience expected him to say "oil", but instead he said "fresh water". He went on to explain that falling water tables in China would soon make China unable to feed its population. This would not cause famine in China itself because of the strength of the Chinese economy, which would allow the Chinese to purchase grain on the world market. However, shortages of fresh water in China would indeed cause famine, for example in Africa, because Chinese demand for grain would raise prices on the world market beyond the ability of poor countries to pay.

[8] http://wcr.unhabitat.org/

Figure 5.11: **Lester R. Brown**

5.9 Predictions of drought in the Stern Review

According to a report presented to the Oxford Institute of Economic Policy by Sir Nicholas Stern on 31 January, 2006, areas likely to lose up to 30% of their rainfall by the 2050's because of climate change include much of the United States, Brazil, the Mediterranean region, Eastern Russia and Belarus, the Middle East, Southern Africa and Southern Australia. Meanwhile rainfall is predicted to increase up to 30% in Central Africa, Pakistan, India, Bangladesh, Siberia, and much of China.

Stern and his team point out that "We can... expect to see changes in the Indian monsoon, which could have a huge impact on the lives of hundreds of millions of people in India, Pakistan and Bangladesh. Most climate models suggest that the monsoon will change, although there is still uncertainty about exactly how. Nevertheless, small changes in the monsoon could have a huge impact. Today, a fluctuation of just 10% in either direction from average monsoon rainfall is known to cause either severe flooding or drought. A weak summer monsoon, for example, can lead to poor harvests and food shortages among the rural population - two-thirds of India's almost 1.1 billion people. Heavier-than-usual monsoon downpours can also have devastating consequences..."

In some regions, melting of glaciers can be serious from the standpoint of dry-season water supplies. For example, melts from glaciers in the Hindu Kush and the Himalayas now supply much of Asia, including China and India, with a dry-season water supply. Complete melting of these glacial systems would cause an exaggerated runoff for a few decades, after which there would be a drying out of some of the most densely populated regions of the world.

5.10 Ocean current changes and failure of monsoons

It is expected that climate change will affect ocean currents, and hence also affect monsoon rainfall. We are already experiencing a diversion of the Gulf Stream due to southward currents of cold water from melting ice in the Arctic. This has caused what is known as the *North Atlantic Anomaly*. While most regions of the world are experiencing rising

temperatures, the North Atlantic and several northern European countries are exceptions to this rule, and have cooled. Complete failure of the Gulf Stream would lead to much colder temperatures in Europe.

Changes in ocean currents have already lead to the failure of the West African Monsoon, and this has already produced severe food insecurity in West Africa.

In the future, climate-changed ocean currents may lead to failures of monsoons in South-east Asia, and thus damage the food supply of almost two billion people.

5.11 Falling water tables around the world

Under many desert areas of the world are deeply buried water tables formed during glacial periods when the climate of these regions was wetter. These regions include the Middle East and large parts of Africa. Water can be withdrawn from such ancient reservoirs by deep wells and pumping, but only for a limited amount of time.

In oil-rich Saudi Arabia, petroenergy is used to drill wells for ancient water and to bring it to the surface. Much of this water is used to irrigate wheat fields, and this is done to such an extent that Saudi Arabia exports wheat. The country is, in effect, exporting its ancient heritage of water, a policy that it may, in time, regret. A similarly short-sighted project is Muammar Qaddafi's enormous pipeline, which will bring water from ancient sub-desert reservoirs to coastal cities.

In the United States, the great Ogallala aquifer is being overdrawn. This aquifer is an enormous stratum of water-saturated sand and gravel under-lying parts of northern Texas, Oklahoma, New Mexico, Kansas, Colorado, Nebraska, Wyoming and South Dakota. The average thickness of the aquifer is about 70 meters. The rate of water withdrawal from the aquifer exceeds the rate of recharge by a factor of eight.

Thus we can see that in many regions, the earth's present population is living on its inheritance of water, rather than its income. This fact, coupled with rapidly increasing populations and climate change, may contribute to a very serious food crisis partway through the 21st century.

5.12 Glacial melting and summer water supplies

The summer water supplies of both China and India are threatened by the melting of glaciers. The Gangotri glacier, which is the principle glacier feeding India's great Ganges River, is reported to be melting at an accelerating rate, and it could disappear within a few decades. If this happens,the Ganges could become seasonal, flowing only during the monsoon season. Chinese agriculture is also threatened by disappearing Himalayan glaciers, in this case those on the Tibet-Quinghai Plateau. The respected Chinese glaciologist Yao Tandong estimates that the glaciers feeding the Yangtze and Yellow Rivers are

disappearing at the rate of 7% per year.[9]

5.13 Advances in desalinization technology

Scientists at the Massachusetts Institute of Technology have developed a new desalinization process, called shock electrodialysis. In this process. water flows through a porous material -in this case, made of tiny glass particles, called a frit - with membranes or electrodes sandwiching the porous material on each side. When an electric current flows through the system, the salty water divides into regions where the salt concentration is either depleted or enriched. When that current is increased to a certain point, it generates a shockwave between these two zones, sharply dividing the streams and allowing the fresh and salty regions to be separated by a simple physical barrier at the center of the flow.

"It generates a very strong gradient," says Martin Bazant, a researcher involved with the project[10].

Even though the system can use membranes on each side of the porous material, Bazant explains, the water flows across those membranes, not through them. That means they are not as vulnerable to fouling - a buildup of filtered material - or to degradation due to water pressure, as happens with conventional membrane-based desalination, including conventional electrodialysis. "The salt doesn't have to push through something," Bazant says. "The charged salt particles, or ions, just move to one side".

5.14 Sustainable future populations

In an important and detailed study entitled *Will Limited Land, Water, and Energy Control Human Population Numbers in the Future?*, David Pimentel et al. [11] discuss the problem of agriculture and global population in the post fossil fuel era. Here are some quotations from the article:

"Nearly 60% of the world's human population is malnourished and the numbers are growing. Shortages of basic foods related to decreases in per capita cropland, water, and fossil energy resources contribute to spreading malnutrition and other diseases. The suggestion is that in the future only a smaller number of people will have access to adequate nourishment. In about 100 years, when it is reported that the planet will run out of fossil energy, we suggest that a world population of about two billion might be sustainable if it relies on renewable energy technologies and also reduces per capita use of the earth's natural resources.

"Developed and developing nations need to provide a good quality life for their people while coping with rapid population growth, but 'Population is the issue no one wants

[9] http://www.commondreams.org/news/2015/08/04/global-glaciers-melting-three-times-rate-20th-century

[10] He was quoted in an article published in *MIT News*, November 12, 2015

[11] D. Pimentel et al., Human Ecology DOI 10.1007/s10745-010-9346-y, (2010)

to touch' (Meadows 2000). The current world population is about 6.8 billion. Based on the present growth rate of 1.2% per year, the population is projected to double in approximately 58 years (Chiras 2006; PRB 2008). Because population growth cannot continue indefinitely, society can either voluntarily control its numbers or let natural forces such as disease, malnutrition, and other disasters limit human numbers (Bartlett 1997-98; Pimentel et al. 1999). Increasing human numbers especially in urban areas, and increasing pollution of food, water, air, and soil by pathogenic disease organisms and chemicals, are causing a rapid increase in the prevalence of disease and human mortality (Murray and Lopez 1996; Pimentel et al. 2007). Currently, more than 3.7 billion humans are malnourished worldwide - the largest number ever (WHO 2005a, b).

"The planet's numerous environmental problems highlight the urgent need to evaluate available land, water, and energy resources and how they relate to the requirements of a rapidly growing human population (Pimentel and Pimentel 2008). In this article we assess the carrying capacity of the Earth's natural resources, and suggest that humans should voluntarily limit their population growth, rather than letting natural forces control their numbers (Ferguson 1998; Pimentel et al. 1999). In addition, we suggest appropriate policies and technologies that would improve standards of living and quality of life worldwide...

"In 1960, when the world population numbered about 3 billion, approximately 0.5 ha of cropland was available per capita worldwide. This half a hectare is needed to provide a diverse, healthy, nutritious diet of plant and animal products..."

Pimentel et al. state that worldwide, the average cropland per capita has now fallen to 0.22 hectares. This number will continue to fall because global population is increasing at the rate of almost one billion people per decade, while the global area available for cropland is not increasing. On the contrary, it is decreasing because of desertification, erosion, salination and urban sprawl. Pimentel et al.state that cropland is being degraded and lost at a rate of more than 20 million hectares per year-

The current cropland per capita in the United States is 0.56 hectares, and thus still quite large, but in China, the figure is dangerously low: only 0.1 hectares. China will soon be unable to feed its population and will have to buy grain on the world market. As Lester Brown pointed out in his Copenhagen lecture, China will be able to import grain because of its strong economy, but this will raise food prices and will cause widespread famine in other parts of the world.

Added to the agricultural and environmental problems, are problems of finance and distribution. Famines can occur even when grain is available somewhere in the world, because those who are threatened with starvation may not be able to pay for the grain, or for its transportation. The economic laws of supply and demand are not able to solve this type of problem. One says that there is no "demand" for the food (meaning demand in the economic sense), even though people are in fact starving.

What is the optimum population of the world? It is certainly not the maximum number that can be squeezed onto the globe by eradicating every species of plant and animal that cannot be eaten. The optimum global population is one that can be supported in comfort, equality and dignity - and with respect for the environment.

In 1848 (when there were just over one billion people in the world), John Stuart Mill

described the optimal global population in the following words:

"The density of population necessary to enable mankind to obtain, in the greatest degree, all the advantages of cooperation and social intercourse, has, in the most populous countries, been attained. A population may be too crowded, although all be amply supplied with food and raiment."

"... Nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings; every flowery waste or natural pasture plowed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture. If the earth must lose that great portion of its pleasantness which it owes to things that the unlimited increase of wealth and population would extirpate from it, for the mere purpose of enabling it to support a larger, but not better or happier population, I sincerely hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it."[12]

Dennis Meadows, one of the authors of *Limits to Growth*, stated recently that the optimum human population in the distant future may be about 2 billion people.

But what about the near future? Will the global population of humans crash catastrophically after having exceeded the carrying capacity of the environment? There is certainly a danger that this will happen - a danger that the 21st century will bring very large scale famines to vulnerable parts of the world, because modern energy-intensive agriculture will be dealt a severe blow by prohibitively high petroleum prices. At present, there are only a few major food-exporting countries, notably the United States, Canada, Australia and Argentina. There is a danger that within a few decades, the United States will no longer be able to export food because of falling production and because of the demands of a growing population. We should be aware of these serious future problems if we are to have a chance of avoiding them.

5.15 The demographic transition

The developed industrial nations of the modern world have gone through a process known as the "demographic transition" - a shift from an equilibrium where population growth is held in check by the grim Malthusian forces of disease, starvation and war, to one where it is held in check by birth control and late marriage.

The transition begins with a fall in the death rate, caused by various factors, among which the most important is the application of scientific knowledge to the prevention of disease. Malthus gives the following list of some of the causes of high death rates: "...unwholesome occupations, severe labour and exposure to the seasons, extreme poverty, bad nursing of children, great towns, excesses of all kinds, the whole train of common

[12] John Stuart Mill, *Principles of Political Economy, With Some of Their Applications to Social Philosophy*, (1848).

diseases and epidemics, wars, plague and famine." The demographic transition begins when some of the causes of high death rates are removed.

Cultural patterns require some time to adjust to the lowered death rate, and so the birth rate continues to be high. Families continue to have six or seven children, just as they did when most of the children died before having children of their own. Therefore, at the start of the demographic transition, the population increases sharply. After a certain amount of time, however, cultural patterns usually adjust to the lowered death rate, and a new equilibrium is established, where both the birth rate and the death rate are low.

In Europe, this period of adjustment required about two hundred years. In 1750, the death rate began to fall sharply: By 1800, it had been cut in half, from 35 deaths per thousand people in 1750 to 18 in 1800; and it continued to fall. Meanwhile, the birth rate did not fall, but even increased to 40 births per thousand per year in 1800. Thus the number of children born every year was more than twice the number needed to compensate for the deaths!

By 1800, the population was increasing by more than two percent every year. In 1750, the population of Europe was 150 million; by 1800, it was roughly 220 million; by 1950 it had exceeded 540 million, and in 1970 it was 646 million.

Meanwhile the achievements of medical science and the reduction of the effects of famine and warfare had been affecting the rest of the world: In 1750, the non-European population of the world was only 585 million. By 1850 it had reached 877 million. During the century between 1850 and 1950, the population of Asia, Africa and Latin America more than doubled, reaching 1.8 billion in 1950. In the twenty years between 1950 and 1970, the population of Asia, Africa and Latin America increased still more sharply, and in 1970, this segment of the world's population reached 2.6 billion, bringing the world total to 3.6 billion. The fastest increase was in Latin America, where population almost doubled during the twenty years between 1950 and 1970.

The latest figures show that population has stabilized or in some cases is even decreasing in Europe, Russia, Canada, Japan, Cuba and New Zealand. In Argentina, the United States, China, Myanmar, Thailand and Australia, the rates of population increase are moderate - 0.6%-1.0%; but even this moderate rate of increase will have a heavy ecological impact, particularly in the United States, with its high rates of consumption.

The population of the remainder of the world is increasing at breakneck speed - 2%-4% per year - and it cannot continue to expand at this rate for very much longer without producing widespread famines, since modern intensive agriculture cannot be sustained beyond the end of the fossil fuel era. The threat of catastrophic future famines makes it vital that all countries that have not completed the demographic transition should do so as rapidly as possible.

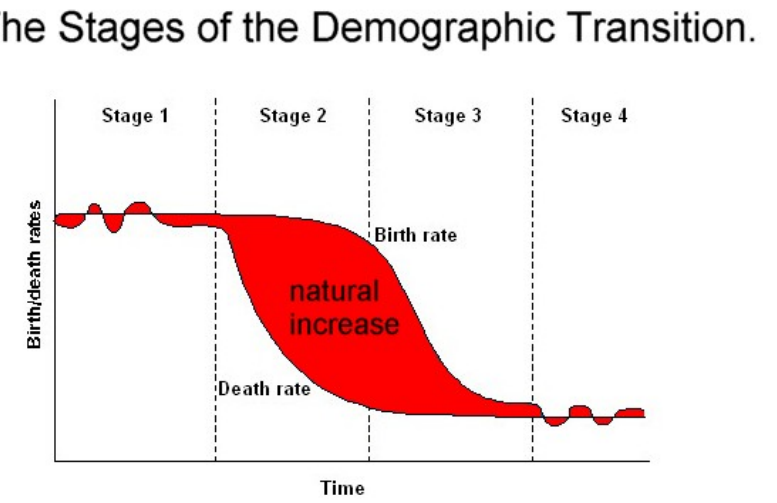

Figure 5.12: **The demographic transition.**

5.16 Urbanization

The global rate of population growth has slowed from 2.0 percent per year in 1972 to 1.7 percent per year in 1987; and one can hope that it will continue to fall. However, it is still very high in most developing countries. For example, in Kenya, the population growth rate is 4.0 percent per year, which means that the population of Kenya will double in seventeen years.

During the 60 years between 1920 and 1980 the urban population of the developing countries increased by a factor of 10, from 100 million to almost a billion. In 1950, the population of Sao Paulo in Brazil was 2.7 million. By 1980, it had grown to 12.6 million; and it is expected to reach 24.0 million by the year 2000. Mexico City too has grown explosively to an unmanageable size. In 1950, the population of Mexico City was 3.05 million; in 1982 it was 16.0 million; and the population in 2000 was 17.8 million.

A similar explosive growth of cities can be seen in Africa and in Asia. In 1968, Lusaka, the capital of Zambia, and Lagos, the capital of Nigeria, were both growing at the rate of 14 percent per year, doubling in size every 5 years. In 1950, Nairobi, the capital of Kenya, had a population of 0.14 million. In a 1999 census, it was estimated to be between 3 and 4 million, having increased by a factor of 25.

In 1972, the population of Calcutta was 7.5 million. By the turn of the century in 2000, it had almost doubled in size. This rapid growth produced an increase in the poverty and pollution from which Calcutta already suffered in the 1970's. The Hooghly estuary near Calcutta is choked with untreated industrial waste and sewage, and a large percentage of Calcutta's citizens suffer from respiratory diseases related to air pollution.

Governments in the third world, struggling to provide clean water, sanitation, roads, schools, medical help and jobs for all their citizens, are defeated by rapidly growing urban

Figure 5.13: **Because of the threat of widespread famine, it is vital that all countries should complete the demographic transition as quickly as possible.**

Figure 5.14: **Sir Partha Dasgupta of Cambridge University has pointed out that all the changes needed for population stabilization are desirable in themselves. These include education for women, higher status for women, state provision of old-age help for the poor, universal health care, and making safe drinking water available near to dwellings.**

populations. Often the makeshift shantytowns inhabited by new arrivals have no piped water; or when water systems exist, the pressures may be so low that sewage seeps into the system.

Many homeless children, left to fend for themselves, sleep and forage in the streets of third world cities. These conditions have tended to become worse with time rather than better. Whatever gains governments can make are immediately canceled by growing populations.

5.17 Achieving economic equality

Today's world is characterized by intolerable economic inequalities, both between nations and within nations. A group of countries including (among others) Japan, Germany, France, the United Kingdom and the United States, has only 13% of the world's population, but receives 45% of the global PPP[13] income. By contrast, a second group, including 2.1 Billion people (45% of the world's population) receives only 9% of the global PPP income. Another indicator of inequality is the fact that the 50 million richest people in the world receive as much as the 2,700 million poorest.

18 million of our fellow humans die each year from poverty-related causes. Each year, 11 million children die before reaching their fifth birthday. 1.1 billion people live on less than $1 per day; 2.7 billion live on less than $2.

At the United Nations Conference on Population and Development, held in Cairo in September, 1994, a theme which emerged very clearly was that one of the most important keys to controlling the global population explosion is giving women better education and equal rights. These goals are desirable for their own sake, and for the sake of the uniquely life-oriented point of view which women can give us; but in addition, education and improved status for women have shown themselves to be closely connected with lowered birth rates. When women lack education and independent careers outside the home, they can be forced into the role of baby-producing machines by men who do not share in the drudgery of cooking, washing and cleaning; but when women have educational, legal, economic, social and political equality with men, experience has shown that they choose to limit their families to a moderate size.

As glaciers melt in the Himalayas, depriving India and China of summer water supplies; as sea levels rise, drowning the fertile rice fields of Viet Nam and Bangladesh; as drought threatens the productivity of grain-producing regions of North America; and as the end of the fossil fuel era impacts modern high-yield agriculture, there is a threat of wide-spread famine. There is a danger that the 1.5 billion people who are undernourished today will not survive an even more food-scarce future.

People threatened with famine will become refugees, desperately seeking entry into countries where food shortages are less acute. Wars, such as those currently waged in the Middle East, will add to the problem.

[13]Purchasing Power Parity

Figure 5.15: **Education of women and higher status for women are vitally important measures, not only for their own sake, but also because these social reforms have proved to be the key to lower birth rates.**

What can we do to avoid this crisis, or at least to reduce its severity? We must urgently address the problem of climate change; and we must shift money from military expenditure to the support of birth control programs and agricultural research. We must also replace the institution of war by a system of effective global governance and enforcible international laws.

5.18 Achieving a steady-state economic system

Endless economic growth on a finite planet is a logical impossibility. Just as population growth is limited by ecological constraints, so too is the growth of resource-using and pollution-producing industrial production. Culture, of course, can and should continue to grow,

A number of economists have studied this problem, and in particular, outstanding contributions have been made by Frederick Soddy, Nickolas Georgiescu-Roegan and Herman Daly. These authors have taken into account the role which entropy plays in economics.

5.19 Harmful effects of industrialized farming

Pharming

A major global public health crisis may soon be produced by the wholesale use of antibiotics in the food of healthy farm animals. The resistance factors produced by shovelling

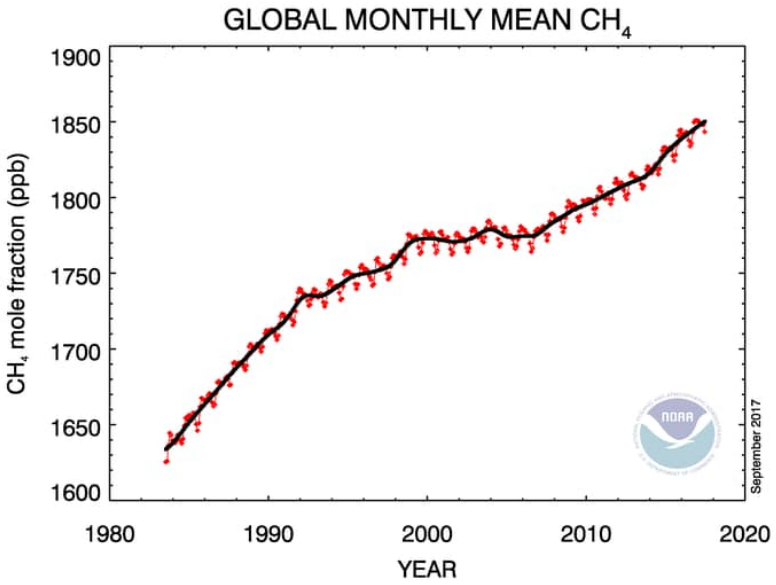

Figure 5.16: **Methane emissions are steadily increasing. A new report has shown ruminants are largely responsible for increases in rates of emission.**

antibiotics into animal food produces resistance factors (plasmids) which can easily be transferred to human pathogens. A related problem is the excessive use of pesticides and artificial fossil-fuel-derived fertilizers in agriculture. Pharming is not a joke. It is a serious threat.[14]

Meat and methane

Methane is an extremely powerful greenhouse gas. and it is emitted in large quantities by ruminants, such as cattle produced for beef. A new report[15] finds that cattle are not the biggest contributor to the annual methane budget in the atmosphere, but they may be the biggest contributor to increases in methane emissions over recent years.

[14]http://ecowatch.com/2014/03/06/misuse-antibiotics-fatal-superbug-crisis/
http://ecowatch.com/2013/12/06/8-scary-facts-about-antibiotic-resistance/
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https://pwccc.wordpress.com/programa/

[15]J. Wolf et al., *Revised methane emissions factors and spatially distributed annual carbon fluxes for global livestock*, Carbon Balance and Management 2017, 12:16

One must also remember that by eating less meat, and in particular less beef, we can shorten the food chain and thus help famine-threatened populations.

Pesticides, artificial fertilizers and topsoil

A closely analogous danger results from the overuse of pesticides and petroleum-derived fertilizers in agriculture. A very serious problem with Green Revolution plant varieties is that they require heavy inputs of pesticides, fertilizers and irrigation. Because of this, the use of high-yield varieties contributes to social inequality, since only rich farmers can afford the necessary inputs. Monocultures, such as the Green Revolution varieties may also prove to be vulnerable to future plant diseases, such as the epidemic that caused the Irish Potato Famine in 1845. Even more importantly, pesticides, fertilizers and irrigation all depend on the use of fossil fuels. One must ask, therefore, whether high-yield agriculture can be maintained in the post-fossil-fuel era.

Topsoil is degraded by excessive use of pesticides and artificial fertilizers. Natural topsoil is rich in organic material, which contains sequestered carbon that would otherwise be present in our atmosphere in the form of greenhouse gases. In addition, natural topsoil contains an extraordinarily rich diversity of bacteria and worms that act to convert agricultural wastes from one year's harvest into nutrients for the growth of next year's crop. Pesticides kill these vital organisms, and make the use of artificial fertilizers necessary.

Finally, many small individual farmers, whose methods are sustainable, are being eliminated by secret land-grabs or put out of business because they cannot compete with unsustainable high-yield agriculture. Traditional agriculture contains a wealth of knowledge and biodiversity, which it would be wise for the world to preserve.

Suggestions for further reading

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Chapter 6

THE GLOBAL HUMAN FOOTPRINT

6.1 How many earths does it take to support us?

The total ecological footprint of humanity is a concept used to measure the relationship between the resources that humans demand from their environment, compared with the ability of nature to provide those resources. In recent years humans have been asking the earth to provide the with much more than the earth can regenerate. Our collective footprint on the face of nature has become too large.

Here are some quotations from the homepage of the Footprint Network organization:[1]

"If a population's Ecological Footprint exceeds the region's biocapacity, that region runs an ecological deficit. Its demand for the goods and services that its land and seas can provide - fruits and vegetables, meat, fish, wood, cotton for clothing, and carbon dioxide absorption - exceeds what the region's ecosystems can renew. A region in ecological deficit meets demand by importing, liquidating its own ecological assets (such as overfishing), and/or emitting carbon dioxide into the atmosphere. If a region's biocapacity exceeds its Ecological Footprint, it has an ecological reserve.

"Conceived in 1990 by Mathis Wackernagel and William Rees at the University of British Columbia, the Ecological Footprint launched the broader Footprint movement, including the carbon Footprint, and is now widely used by scientists, businesses, governments, individuals, and institutions working to monitor ecological resource use and advance sustainable development.

"A rich introduction to the theory and practice of the approach is available in the book Ecological Footprint: Managing Our Biocapacity Budget (2019)."

[1] https://www.footprintnetwork.org/our-work/ecological-footprint/

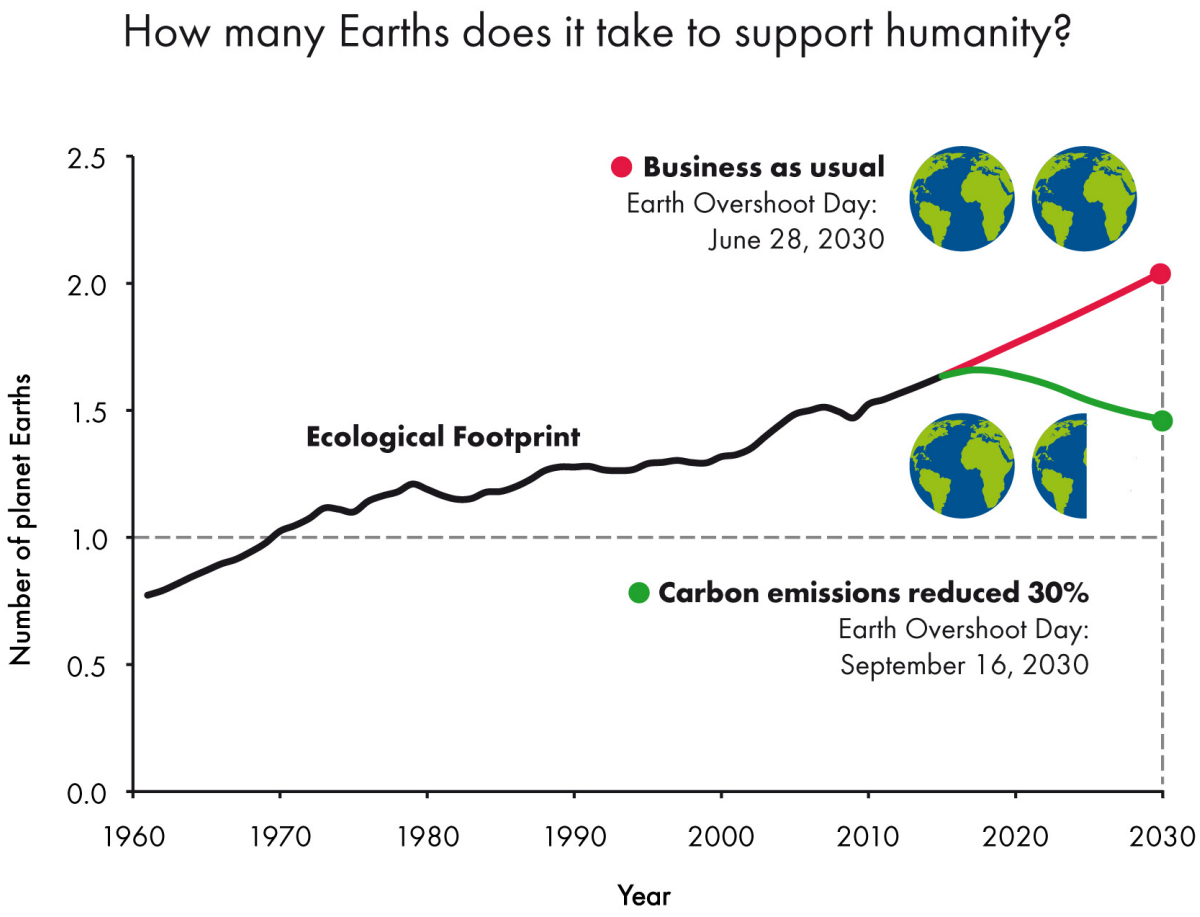


Figure 6.1: **The business as usual course would lead us to disaster.**

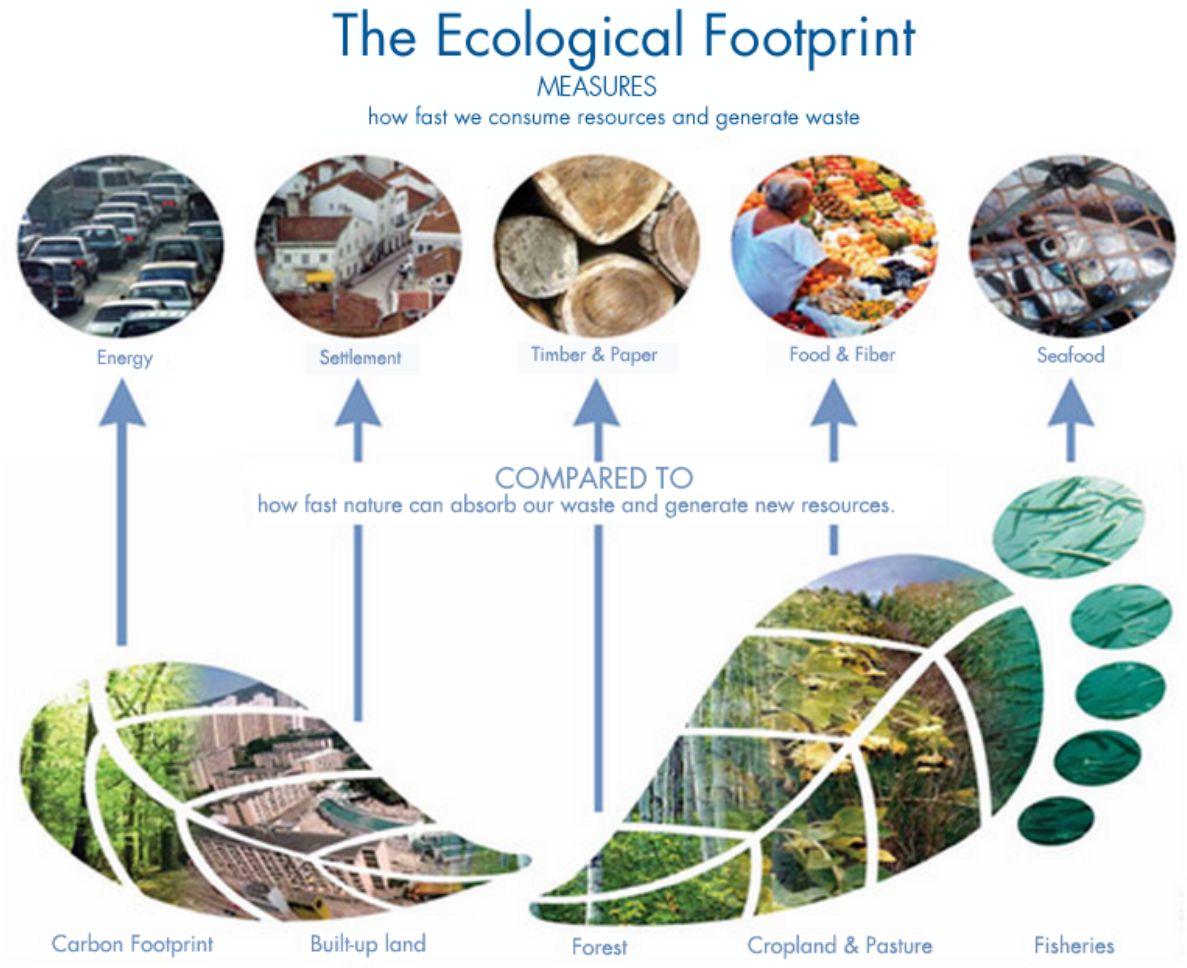


Figure 6.2: **Both the Ecological Footprint and biocapacity are expressed in global hectares - globally comparable, standardized hectares with world average productivity.**

6.2 Overuse of pesticides and the insect apocalypse

Loss of flying insects, especially bees

Studies have shown an annual decline of 5.2% in flying insect biomass found in nature reserves in Germany - about 75% loss in 26 years.

In the United States the managed bee populations have declined dramatically. According to one study, for the single year, from April 1, 2018, to April 1, 2019, the managed bee population decreased by 40.7%.

Overuse of pesticides degrades topsoil

It is not only the loss of bees and other pollinator insects that is dangerous to agriculture. The excessive use of pesticides and other agricultural chemicals also degrades topsoil. Normally, topsoil contains richly numerous and diverse populations of tiny worms and bacteria, that aid the recycling of crop residue from previous years into nutrients for plant growth. However, the overuse of pesticides and other agricultural chemicals kills these vitally important populations. Carbon from the dead topsoil is released into the atmosphere, thus increasing the concentrations of dangerous greenhouse gases. Having killed the living topsoil, farmers then find that they need increased quantities of petroleum-derived fertilizers to make their crops grow.

The Stockholm Convention on Persistent Organic Pollutants

An environmental treaty, signed in 2001 and effective since May, 2004, aims at restricting the production and use of persistent organic pollutants (POPs). These are defined by the United Nations Environmental Institute as "chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment". Besides DDT, the Stockholm Treaty also lists Aldrin, α-Hexachlorocyclohexane, β-Hexachlorocyclohexane, Chlordane, Chlordecone, Decabromodiphenyl ether, Dicofol, Dieldrin, Endosulfan, Endrin, Heptachlor, Hexabromobiphenyl, Hexabromocyclododecane, Hexabromdiphenylether, Hexachlorobenzene, Hexachlorobutadiene, Lindane, Mirex, Pentachlorobenzene, Pentachlorophenol, Perfluorooctanoic acid, Perfluorooctane sulfonic acid, Polychlorinated biphenyls, Polychlorinated dibenzodioxins, Polychlorinated naphthalenes, Tetrabromodiphenyl ether, Short-chain chlorinated paraffins, and Toxaphene.

Although some critics have claimed that the treaty is responsible for the continuing death toll from malaria, in reality it specifically permits the public health use of DDT for the control of malaria-carrying mosquitoes. In 2016, there were 216 million cases of malaria worldwide, resulting in an estimated 445,000 to 731,000 deaths.

Figure 6.3: **20 May 2019, Rome - The global decline in bee populations poses a serious threat to a wide variety of plants critical to human well-being and livelihoods, and countries should do more to safeguard our key allies in the fight against hunger and malnutrition, FAO stressed today as it marked UN World Bee Day. Bees and other pollinator are declining in abundance in many parts of the world largely due to intensive farming practices, mono-cropping, excessive use of agricultural chemicals and higher temperatures associated with climate change, affecting not only crop yields but also nutrition. If this trend continues, nutritious crops such as fruits, nuts, and many vegetables will be substituted increasingly by staple crops like rice, corn, and potatoes, eventually resulting in an imbalanced diet.**

6.3 The Silent Spring

Dangers from pesticide pollution

Rachel Carson's most influential book, *The Silent Spring*, was published in 1962, when she was already suffering from breast cancer. Eventually it sold over two million copies. The book expresses Carson's worries about the environmental consequences of overuse of pesticides, such as DDT, which were killing not only their targeted pests, but also many vitally important insects, as well as causing health problems in humans. Part of the anger that Carson expressed in the book may have come because the cancer from which she was suffering could have been caused by mutagenic pesticides.

The town was fictitious, but the problems were real

The Silent Spring begins by describing a fictitious Midwestern American town, where people are mysteriously suffering and dying from a variety of unexplained illnesses previously unseen by doctors. Sheep and cattle, fish in the river, and birds, all sicken and die. Orchards bear no fruit add vegetation withers. It gradually becomes clear that the people of the town are themselves to blame. That have been poisoning themselves and their environment by overuse of pesticides.

Some quotations from *The Silent Spring*

Here are two quotations from the book:

As crude a weapon as the cave man's club, the chemical barrage has been hurled against the fabric of life - a fabric on the one hand delicate and destructible, on the other miraculously tough and resilient, and capable of striking back in unexpected ways... It is our alarming misfortune that so primitive a science has armed itself with the most modern and terrible weapons, and that in turning them against the insects it has also turned them against the earth...

Among the herbicides are some that are classified as 'mutagens,' or agents capable of modifying the genes, the materials of heredity. We are rightly appalled by the genetic effects of radiation; how then, can we be indifferent to the same effect in chemicals that we disseminate widely in our environment?

Although extremely ill with cancer and in constant pain, Carson gave newspaper interviews and appeared on television to make her case. In July, 1962, the US Department of agriculture issued the following statement: **"Miss Carson provides a lucid description of the real and potential dangers of misusing chemical pesticides... She expresses the concern of many people about the effect of chemical pesticides on birds, animals and people. We are fully aware of and share this concern."**

'Silent Spring' Is Now Noisy Summer

Pesticides Industry Up in Arms Over a New Book

Rachel Carson Stirs Conflict—Producers Are Crying 'Foul'

By JOHN M. LEE

The $500,000,000 pesticides industry has been highly irritated by a quiet woman author whose previous works on science have been praised for the beauty and precision of the writing.

The author is Rachel Carson, whose "The Sea Around Us" and "The Edge of the Sea" were best sellers in 1951 and 1955. Miss Carson, trained as a marine biologist, wrote gracefully of sea and shore life.

In her latest work, however, Miss Carson is not so gentle,

feuding the use of their products. Hearings have been held in Washington and New York. Statements are being drafted and counter-attacks plotted.

A drowsy midsummer has suddenly been enlivened by the greatest uproar in the pesticides industry since the cranberry scare of 1959.

Miss Carson's new book is entitled "Silent Spring." The title is derived from an idealized situation in which Miss Carson envisions an imaginary town where chemical pollution has silenced "the voices of spring."

Figure 6.4: **Rachel Carson's book, *The Silent Spring*, was controversial, to say the least, but it focused public attention on problems of ecology.**

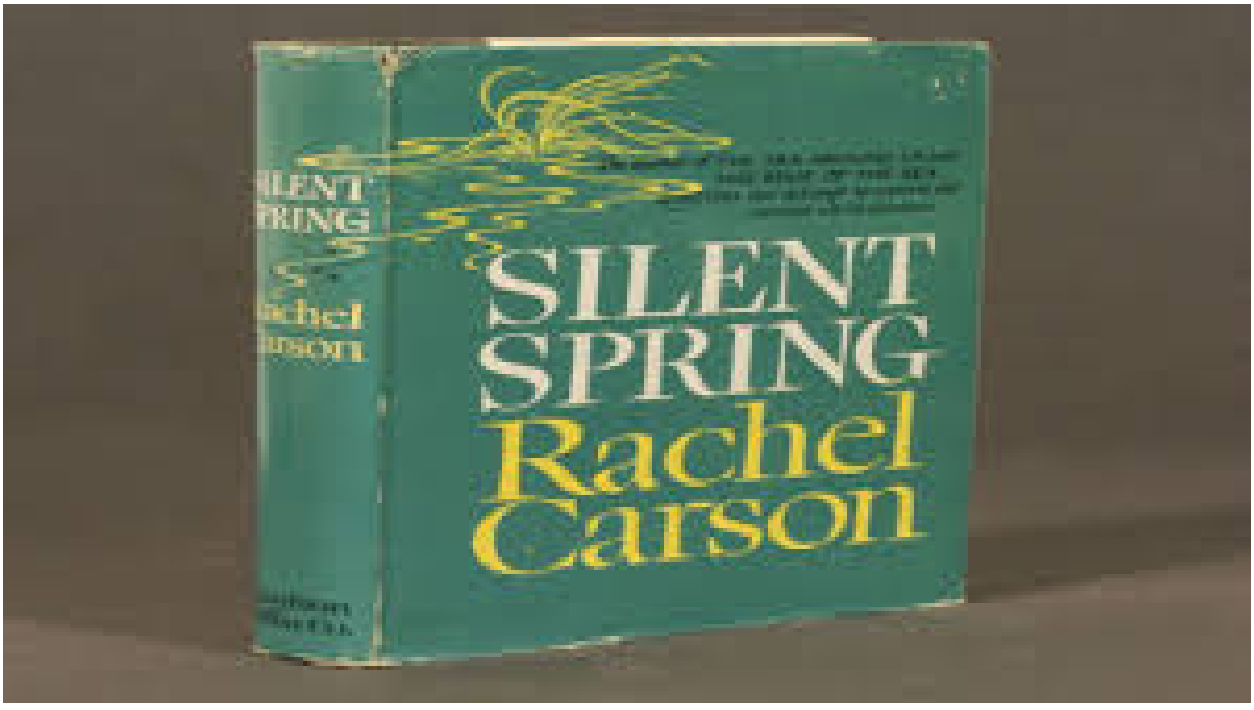


Figure 6.5: ***The Silent Spring*** **was an international best-seller, and it ignited the environmental movement.**

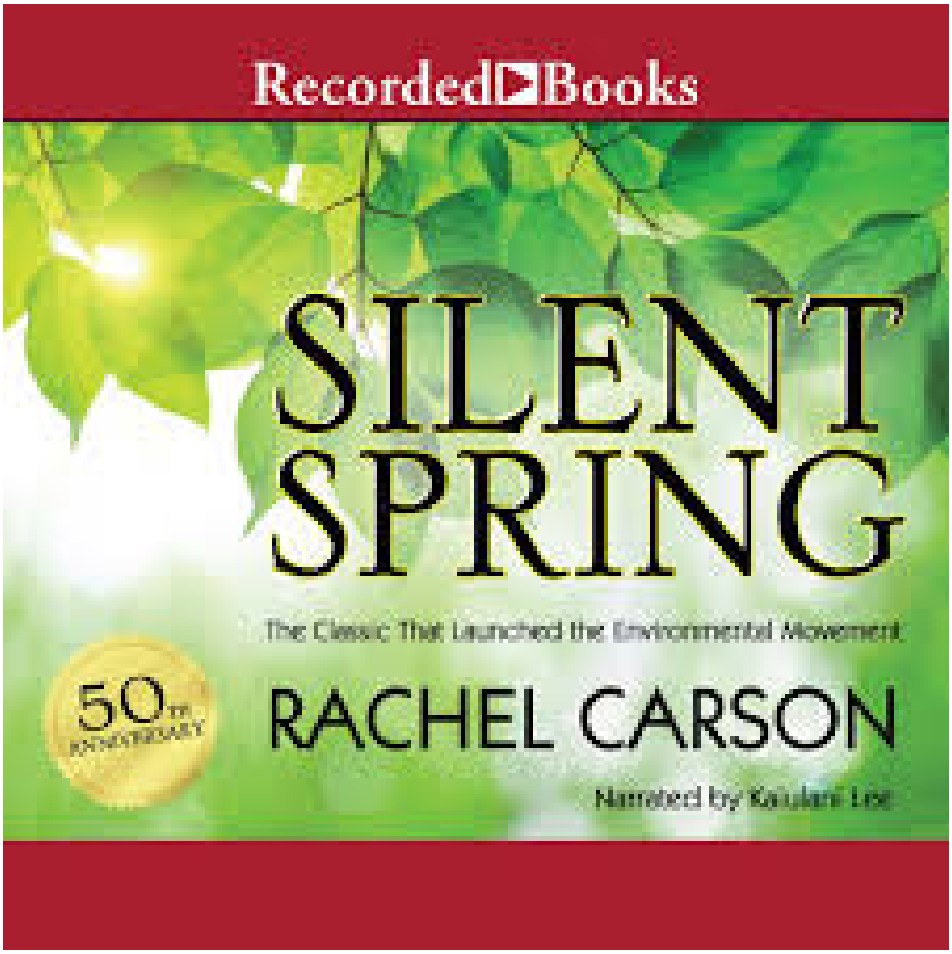


Figure 6.6: **An audio version of *The Silent Spring*.**

Figure 6.7: **As Rachel Carson's influence increased, she began speaking to large audiences.**

Figure 6.8: **Statue of Carson at the Museo Rocsen, Nono, Argentina.**

6.4 Biodiversity loss

According to Wikipedia's article on *Biodiversity Loss*,

"The current rate of global diversity loss is estimated to be 100 to 1000 times higher than the (naturally occurring) background extinction rate and expected to still grow in the upcoming years...

"According to the UN's Global Biodiversity Outlook 2014 estimates that 70 percent of the projected loss of terrestrial biodiversity are caused by agriculture use. Moreover, more than 1/3 of the planet's land surface is utilized for crops and grazing of livestock. Agriculture destroys biodiversity by converting natural habitats to intensely managed systems and by releasing pollutants, including greenhouses gases. Food value chains further amplify impacts including through energy use, transport and waste. The direct effects of urban growth on habitat loss are well understood: Building construction often results in habitat destruction and fragmentation. The rise of urbanization greatly reduced biodiversity when large areas of natural habitat are fragmented. Small habitat patches are unable to support the same level of genetic or taxonomic diversity as they formerly could while some of the more sensitive species may become locally extinct.

"Pollution from burning fossil fuels such as oil, coal and gas can remain in the air as particle pollutants or fall to the ground as acid rain. Acid rain, which is primarily composed of sulfuric and nitric acid, causes acidification of lakes, streams and sensitive forest soils, and contributes to slower forest growth and tree damage at high elevations. Moreover, Carbon dioxide released from burning fossil fuels and biomass, deforestation, and agricultural practices contributes to greenhouse gases, which prevent heat from escaping the earth's surface. With the increase in temperature expected from increasing greenhouse gases, there will be higher levels of air pollution, greater variability in weather patterns, and changes in the distribution of vegetation in the landscape. These two factors play a huge role towards biodiversity loss and entirely depended on human-driven factors."

6.5 Illegal burning for palm oil plantations

According to a recent article published by the Union of Concerned Scientists, "One huge source of global warming emissions associated with palm oil is the draining and burning of the carbon-rich swamps known as peatlands. Peatlands can hold up to 18 to 28 times as much carbon as the forests above them; when they are drained and burned, both carbon and methane are released into the atmosphere - and unless the water table is restored, peatlands continue to decay and release global warming emissions for decades.

"As if that wasn't bad enough, the burning of peatlands releases a dangerous haze into

the air, resulting in severe health impacts and significant economic losses. Each year, more than 100,000 deaths in Southeast Asia can be attributed to particulate matter exposure from landscape fires, many of which are peat fires.

"Beyond its global warming and human health impacts, palm oil production also takes a toll on biodiversity and human rights. Only about 15 percent of native animal species can survive the transition from primary forest to plantation. Among the species vulnerable to palm oil expansion are orangutans, tigers, rhinoceros, and elephants. Furthermore, palm oil growers have also been accused of using forced labor, seizing land from local populations, and other human rights abuses."

Licences to burn forests for palm oil plantations are often granted by corrupt government officials Fortunately, through the efforts of NGO's the public has become increasingly aware of the problem, and supermarkets are being urged to purchase products containing deforestation-free palm oil.

Another recent article[2] states that " Indonesia is being deforested faster than any other country in the world, and it has everything to do with one product: palm oil.

"According to a new study in the journal Nature Climate Change, deforestation in the Southeast Asian archipelago is nearly double the rate in the Amazon. Indonesia is said to have lost 840,000 hectares (3,250 square miles) of forest in 2012 while Brazil - which has four times Indonesia's rainforest - lost a still-massive 460,000 hectares.

"The report's authors found that government figures underestimated the true toll of forest clearing by as much as half. In the last 12 years, it's possible that the destruction of one million hectares of 'primary forest' went unreported.

"The tree-killing spree is largely due to slashing and burning vegetation for the expansion of palm oil plantations to feed growing demand in countries like China and India. Americans and Europeans are still far and away the top consumers per capita - it's estimated that palm oil can be found in roughly half the manufactured goods in any supermarket or drug store. Everything from peanut butter to soap to cosmetics contains the oil in its various forms.

"In Indonesia, where much of the land consists of carbon-rich soil known as peat, the problem is acute. Water-logged peat is commonly found in the jungles of Sumatra and Borneo, and merely exposing it to the air releases carbon dioxide into the atmosphere."

6.6 Jair Bolsonaro's attack on the Amazon rainforest

Beef is killing the rainforest

Beef Production is Killing the Amazon Rainforest. That is the title of an article published by onegreenplanet.org[3]. Here are some excerpts from the article

"The Amazon rainforest has been facing severe deforestation problems for several decades - it has lost about a fifth of its forest in the past three. While there are many

[2]https://news.vice.com/article/indonesia-is-killing-the-planet-for-palm-oil

[3]http://www.onegreenplanet.org/animalsandnature/beef-production-is-killing-the-amazon-rainforest/

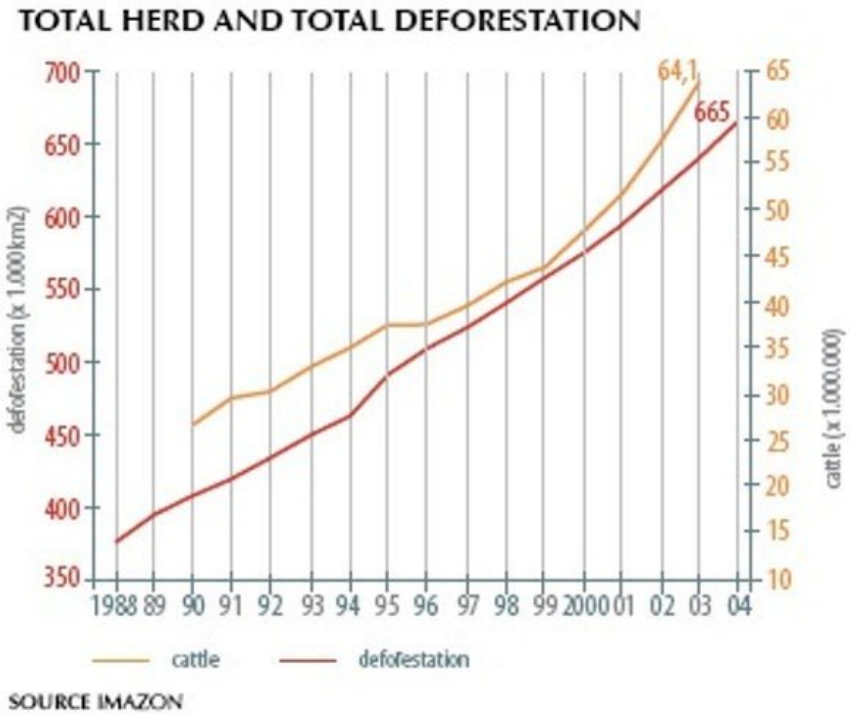


Figure 6.9: **Total cattle herds and total deforestation in Amazonia between 1988 and 2104. Deforestation is measured in thousands of square kilometers, while herd size is measured in millions.**

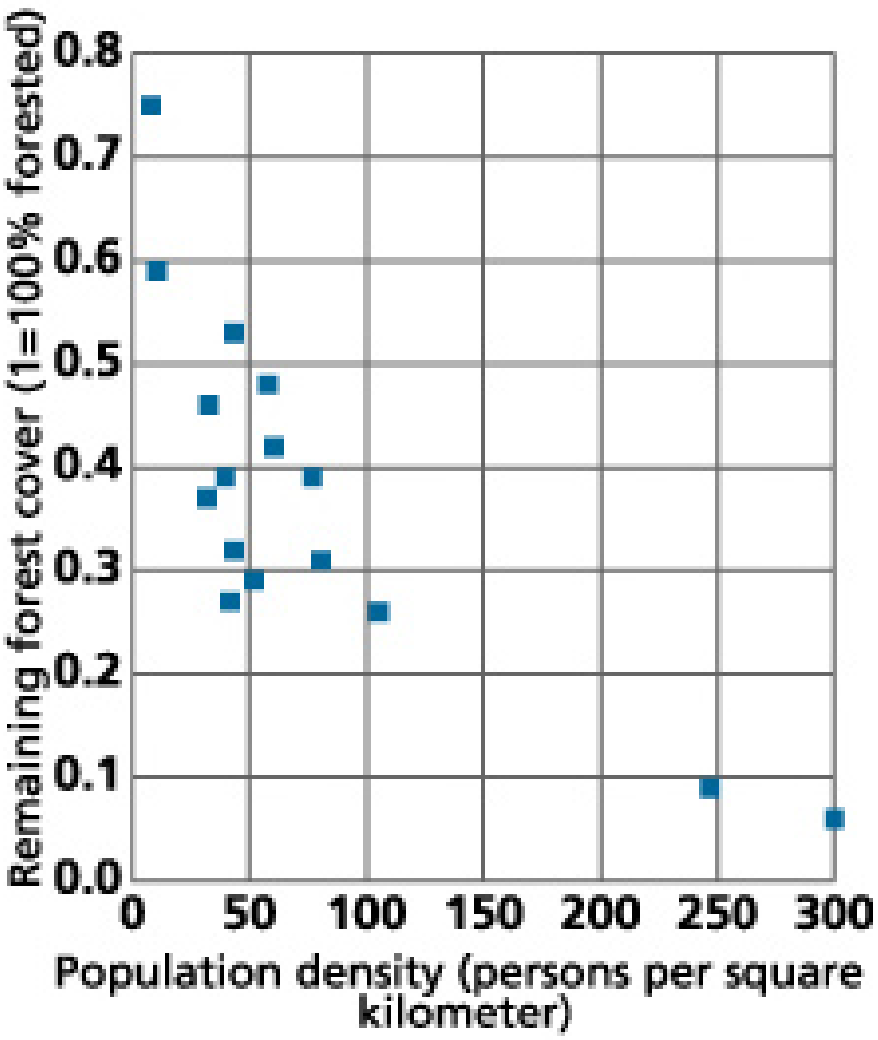


Figure 6.10: **Population density and forest size.**

causes, one of the main causes is cattle ranching, particularly in Brazil. Trees are cut and the land is converted into a pasture for cattle grazing. According to one report, an estimated 70 percent of deforestation in the Amazon basin can be attributed to cattle ranching. Using these numbers, cattle ranching in the Amazon has resulted in the loss of an area larger than the state of Washington.

"The government of Brazil offers loans of billions of dollars to support the expansion of its beef industry. Approximately 200 million pounds of beef is imported by the United States from Central America every year. While the chief importers of Brazilian beef were previously Europe and North America, nowadays Asian countries such as China and Russia consume more Brazilian beef than the European market. So, the demand is increasing day by day.

"With increasing population and increased per capita meat consumption, the rate of deforestation is increasing every day as well. It is expected that by 2018, the beef export will increase 93 percent, thereby increasing Brazil's beef market share of world exports to 61 percent. Beef is the most carbon-intensive form of meat production on the planet. The United Nations Food and Agriculture Organization finds that beef production gives rise to more greenhouse gases than the transportation industry."

Beef production and methane

A cow (or a bull) releases between 70 and 120 kg of methane per year. Methane is a greenhouse gas like carbon dioxide, but the negative effect on the climate of methane (CH_4) is 23 times higher than the effect of CO2. Therefore the release of about 100 kg methane per year for each cow is equivalent to about 2,300 kg CO_2 per year.

World.wide, there are about 1.5 billion cows and bulls. All ruminants (animals which regurgitates food and re-chews it) on the world emit about two billion metric tons of CO_2, equivalents per year. In addition, clearing of tropical forests and rain forests to get more grazing land and farm land is responsible for an extra 2.8 billion metric tons of CO2 emission per year!

According to the Food and Agriculture Organization of the United Nations (FAO) agriculture is responsible for 18% of the total release of greenhouse gases world-wide (this is more than the whole transportation sector). Cattle-breeding is taking a major factor for these greenhouse gas emissions according to FAO. Says Henning Steinfeld, Chief of FAO's Livestock Information and Policy Branch and senior author of the report: "Livestock are one of the most significant contributors to today's most serious environmental problems. Urgent action is required to remedy the situation."

Livestock now use 30 percent of the earth's entire land surface, mostly permanent pasture but also including 33 percent of the global arable land used to producing feed for livestock, the report notes. As forests are cleared to create new pastures, it is a major driver of deforestation, especially in Latin America where, for example, some 70 percent of former forests in the Amazon have been turned over to grazing.

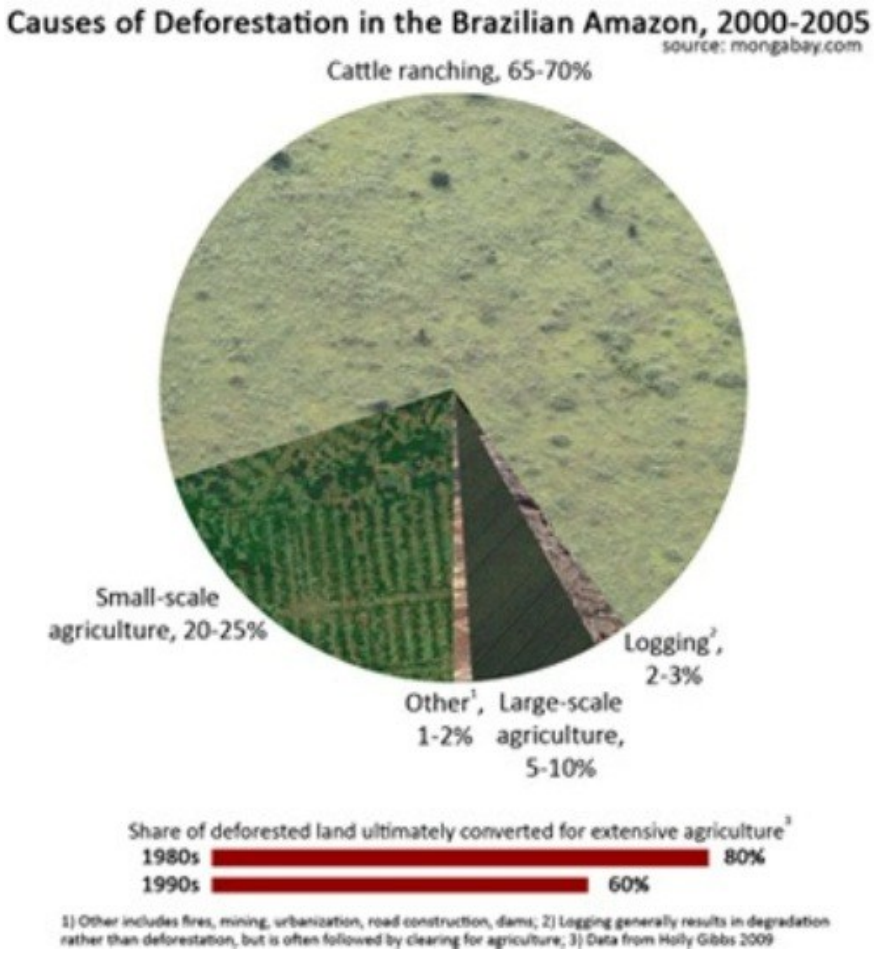


Figure 6.11: **This figure shows the causes of Amazonian deforestation. The largest is beef production.**

Dietary changes can help

You and I can help to save our common future by changing our diets, especially by cutting out beef. Not only does beef production produce methane and destroy rainforests, it also requires much more land per calorie than other forms of agriculture. By switching from beef to other protein-rich foods, we not only substantially reduce greenhouse gas emissions, but we also shorten the food chain, so that more grain will be available to feed the world's growing population. Furthermore a changed diet with less meat would improve our health, since animal fats have been linked with heart disease, circulatory problems and strokes.

6.7 Growing populations and forest loss

Deforestation is occurring at alarming rates, especially in countries that have high levels of population growth.[4] The following table shows the forest loss in some countries where it is particularly high, together with there present and projected populations[5]. In the table, the annual rate of forest loss in the period 2000-2010. measured both in thousands of hectares and in percent. Populations in millions in 2010 are shown, together with projected populations in 2050.

country	forest loss	percent	pop. 2010	pop. 2050
Brazil	-2642	-0.49	194.9	222.8
Australia	-562	-0.37	22.3	31.4
Indonesia	-498	-0.51	239.9	293.5
Nigeria	-410	-3.67	158.4	389.6
Tanzania	-403	-1.13	44.8	138.3
Zimbabwe	-327	-1.88	12.6	20.6
Dem. Rep. Congo	.311	-0.20	66.0	148.5
Myanmar	-310	-0.93	47.9	55.3
Bolivia	-290	-0.49	9.9	16.8
Venezuela	-288	-0.60	28.0	41.8

The main mechanism through which rapid population growth is linked to forest loss is felling forests for the sake of agriculture.

Notice that Nigeria is loosing 3.67% of its forests each year. The population of Nigeria is projected to more than double by 2050, but rising death rates from heat, famine and

[4] http://www.prb.org/Publications/Articles/2004
/PopulationGrowthandDeforestationACriticalandComplexRelationship.aspx

[5] Population Action International, *Why Population Matters to Forests*

conflicts may prevent this. In general, rising death rates from these causes may ultimately lead populations in the tropics to decrease rather than increase.

Population Action International points out that "Deforestation threatens the well-being and livelihoods of millions of people who heavily depend on forest resources. It is particularly devastating for women and children in poor rural communities." The organization recommends that information and materials for family planning be made available to all through universal provision of primary health care.

6.8 Desertification and soil erosion

The Princeton University Dictionary defines *desertification*as "the process of fertile land transforming into desert typically as a result of deforestation, drought or improper/inappropriate agriculture". It is estimated that approximately a billion people are under threat from further expansions of deserts.

Southward expansion of the Gobi desert

The Gobi desert is the fastest moving desert on earth. The rapid southward expansion of the Gobi is mainly due to human activities, such as overgrazing, deforestation and overuse of water. Dust storms from the Gobi desert are becoming more and more frequent. Sand dunes are reportedly forming only 70 km north of Beijing.

The Sahel

Another region in which the threat of desertification is extremely acute is the Sahel, which is the boundary between Africa's Sahara desert to the north and a region of savanna to the south. The Sahel stretches between the Atlantic Ocean and the Red Sea. During the last 50 years, the Sahel has lost approximately 650,000 km^2 of fertile land to the desert, and the boundary of the Sahara has moved 250 km southward.

The southward expansion of the Sahara has been caused partly by climate change, and partly by human activities. Growing human populations have put pressure on the fragile arid environment by overgrazing, tree-cutting for firewood and inappropriate agriculture.

6.9 Forest drying and wildfires: a feedback loop

When climate change produces aridity in a forested region, wildfires produced by lightning, stray sparks from falling stones, or human carelessness become increasingly likely. Forest fires contribute to global warming by releasing CO_2 into the atmosphere and by destroying climate-friendly tree-covered areas. Thus a dangerous feedback loop can be formed, and as was discussed in Chapter 4, with every feedback loop there is an associated tipping point, In the case of forest drying and wildfires, passing the tipping point means that forest cover will be lost irrevocably. We must avoid passing wildfire tipping points through human

activities, such as the deliberate burning of rainforests for the sake of oil palm plantations.

6.10 Degraded forests are carbon emitters

According to an article published in the journal *Science* on 28 September, 2017 [6], degraded tropical forest throughout the world have stopped being carbon absorbers, and are now carbon emitters.

Reporting on the study, *The Guardian*,[7] noted that "Researchers found that forest areas in South America, Africa and Asia - which have until recently played a key role in absorbing greenhouse gases - are now releasing 425 teragrams of carbon annually, which is more than all the traffic in the United States.

"The study went further than any of its predecessors in measuring the impact of disturbance and degradation - the thinning of tree density and the culling of biodiversity below an apparently protected canopy - usually as a result of selective logging, fire, drought and hunting.

"Overall, more carbon was lost to degradation and disturbance than deforestation. The researchers stressed this was an opportunity as well as a concern because it was now possible to identify which areas are being affected and to restore forests before they disappeared completely."

6.11 Replanting forests

Around the world, people interested in replanting forests can take inspiration from the Green Belt Movement, which was founded in 1977 by Wangari Maathai.

The Green Belt Movement organizes women in rural Africa to combat deforestation by planting trees. In this way they restore their main source of fuel for cooking, generate income and stop soil erosion. Since its foundation in 1977, the movement has planted 51 million trees. Over 30,000 women have been trained in forestry, food processing, beekeeping, and other trades. The movement emphasizes economic justice and empowerment of women. This work is particularly valuable in regions of water scarcity, because besides preventing soil erosion, forests prevent the rapid run-off of water.

In order to combat climate change and to prevent southward expansion of the Sahara. the African Union has initiated a project called the Great Green Wall. The project aims at creating a mosaic of green and productive landscapes stretching across Africa, the Sahel region to the Horn of Africa, a strip of forested land 15 km wide and 7,500 km long, stretching from Dakar to Djibouti.

[6] A. Baccini et al., *Tropical forests are a net carbon source based on aboveground measurements of gain and loss*, DOI: 10.1126/science.aam5962

[7] https://www.theguardian.com/environment/2017/sep/28/alarm-as-study-reveals-worlds-tropical-forests-are-huge-carbon-emission-source

Figure 6.12: **Nobel Laureate Wangari Maathai (1940-2011).**

Figure 6.13: **Wangari Maathai speaks about deforestation.**

In China, the Green Great Wall project aims at preventing the expansion of the Gobi desert by planting a 4,500-kilometer-long windbreaking line of forests. The project is expected to be completed by 2050.

Reforestation initiatives also exist in other countries, for example in India, Lebanon, Philippines, Japan, Germany, Canada and the United States.

6.12 Human ecology

By definition, **"Human Ecology is the study of the interactions between man and nature in different cultures. Human Ecology combines the ideas and methods from several disciplines, including anthropology, sociology, biology, economic history and archeology."**

6.13 Paul R. Ehrlich and Anne H. Ehrlich

Education

Paul R. Ehrlich was born in 1932 in Philadelphia, Pennsylvania. He studied zoology at the University of Pennsylvania, and later received a Ph.D. from the University of Kansas, where he specialized in the study of insects. In 1959. Ehrlich joined the staff of Stanford University, where he was appointed to the Bing Professorship in Zoology in 1977.

Involvement in the population debate

In 1967, a lecture on population that Ehrlich gave at the Commonwealth Club of California was broadcast on the radio. Because of the publicity that followed the radio broadcast, Ehrlich was invited by the Sierra Club and Ballantine Books to write a book on the dangers of a human population explosion. Paul R. Ehrlich and his wife, Anne H. Ehrlich together wrote a book entitled *The Population Bomb*, which was published in 1968. Although the book was a joint husband and wife production, the publisher insisted that only Paul's name should appear as author. Although others had written about the dangers of overpopulation, it was this book that brought the problem to a wide audience.

Books by Paul R. Ehrlich

- *How to Know the Butterflies* (1960)
- *Process of Evolution* (1963)
- *Butterflies and Plants: A Study in Coevolution* (1964)
- *The Population Bomb* (1968, revised 1971, updated 1978, re-issued 1988, 1998, 2008 and 2018)
- *Population, Resources, Environments: Issues in Human Ecology* (1970)
- *How to Be a Survivor* (1971)

- *Man and the Ecosphere: Readings from Scientific American* (1971)
- *Population, Resources, Environments: Issues in Human Ecology* Second Edition (1972)
- *Human Ecology: Problems and Solutions* (1973)
- *Introductory Biology* (1973)
- *The End of Affluence* (1975)
- *Biology and Society* (1976)
- *Ecoscience: Population, Resources, Environment* (1978)
- *The Race Bomb* (1978)
- *Extinction* (1981)
- *The Golden Door: International Migration, Mexico, and the United States* (1981)
- *The Cold and the Dark: The World after Nuclear War* (1984, with Carl Sagan, Donald Kennedy, and Walter Orr Roberts)
- *The Machinery of Nature: The Living World Around Us and How it Works* (1986)
- *Earth* (1987, co-authored with Anne Ehrlich)
- *Science of Ecology* (1987, with Joan Roughgarden)
- *The Cassandra Conference: Resources and the Human Predicament* (1988)
- *The Birder's Handbook: A field Guide to the Natural History of North American Birds* (1988, with David S. Dobkin and Darryl Wheye)
- *New World, New Mind: Moving Towards Conscious Evolution* (1988, co-authored with Robert E. Ornstein)
- *The Population Explosion* (1990, with Anne Ehrlich)
- *Healing the Planet: Strategies for Resolving the Environmental Crisis* (1991, co-authored with Anne Ehrlich)
- *Birds in Jeopardy: The Imperiled and Extinct Birds of the United States and Canada, Including Hawaii and Puerto Rico* (1992, with David S. Dobkin and Darryl Wheye)
- *The Stork and the Plow : The Equity Answer to the Human Dilemma* (1995, with Anne Ehrlich and Gretchen C. Daily)
- *A World of Wounds: Ecologists and the Human Dilemma* (1997)
- *Betrayal of Science and Reason: How Anti-Environment Rhetoric Threatens Our Future* (1998, with Anne Ehrlich)
- *Wild Solutions: How Biodiversity is Money in the Bank* (2001, with Andrew Beattie)
- *Human Natures: Genes*, Cultures, and the Human Prospect (2002)
- *One With Nineveh: Politics, Consumption, and the Human Future* (2004, with Anne Ehrlich)
- *On the Wings of Checkerspots: A Model System for Population Biology* (2004, edited volume, co-edited with Ilkka Hanski)
- *The Dominant Animal: Human Evolution and the Environment* (2008, with Anne Ehrlich)
- *Humanity on a Tightrope: Thoughts on Empathy, Family, and Big Changes for a Viable Future* (2010, with Robert E. Ornstein)
- *Conservation Biology for All* (2010, edited volume, co-edited with Navjot S. Sodhi)
- *Hope on Earth: A Conversation* (2014, co-authored with Michael Charles Tobias)

Figure 6.14: **Paul R. Ehrlich in 1974.**

- *Killing the Koala and Poisoning the Prairie: Australia, America and the Environment* (2015, co-authored with Corey J. A. Bradshaw)
- *The Annihilation of Nature: Human Extinction of Birds and Mammals* (2015, with Anne Ehrlich and Gerardo Ceballos)

Figure 6.15: **Ehrlich speaking in 2008.**

Figure 6.16: **Anne H. Ehrlich, Paul Ehrlich's wife, is the co-author of many of his books. I know her personally because of the many Pugwash Conferences that we both have attended. I also know John P. Holdren for the same reason,**

6.14 John P. Holdren

Education

John P. Holdren was born in Pennsylvania in 1944, but grew to in California. He graduated from MIT with a B.Sc. degree in 1965, and was awarded a Ph,D. by Stanford University in 1070, having studied aeronautics, astronautics and plasma physics.

Professor of environmental science

Holdren taught for 13 years at Harvard, and later for more than 20 years at the University of California, Berkeley. His research interests centered on environmental questions. These included global environmental change, population stabilization, energy technologies and policies, ways to reduce the dangers from nuclear weapons and materials, and science and technology policy.

Pugwash Conferences on Science and World Affairs

John P. Holdren served as the Chairman of the Executive Committee of Pugwash Conferences on Science and World Affairs. The Russell-Einstein Manifesto of 1955 called for a meeting of scientists from both sides of the Cold War to try to minimize the danger of a thermonuclear conflict. The first meeting took place at the summer home of the Canadian philanthropist Cyrus Eaton at the small village of Pugwash, Nova Scotia.

From this small beginning, a series of conferences developed, in which scientists, especially physicists, attempted to work for peace, and tried to address urgent global problems related to science, and especially to reduce the danger of a thermonuclear war. In 1995, Pugwash Conferences, and its president, Sir Joseph Rotblat, shared the Nobel Peace Prize. John P. Holdren delivered the acceptance speech on behalf of the organization.

Some books and articles by John P. Holdren

Holdren has authored over 200 articles and papers and has co-authored and co-edited some 20 books and book-length reports including

- *Ecoscience : Population, Resources, Environment* by John P. Holdren, Paul R. Ehrlich, Ann H. Ehrlich
- *Global Ecology* by John P. Holdren and Paul R. Ehrlich
- *The Cassandra Conference : Resources and the Human Predicament* by John P. Holdren and Paul R. Ehrlich
- *Strategic Defense and the Future of the Arms Race : A Pugwash Symposium* by John P. Holdren
- *Energy* by John P. Holdren
- *Science in the White House*. Science, May 2009, 567.[
- *Policy for Energy Technology Innovation. Acting in Time on Energy Policy*, (with Laura Diaz Anadon, Max H. Bazerman, David T. Ellwood, Kelly Sims Gallagher, William H. Hogan, Henry Lee, and Daniel Schrag), Brookings Institution Press, 2009.
- *The Future of Climate Change Policy: The U.S.'s Last Chance to Lead*. Scientific American 2008 Earth 3.0 Supplement. October 13, 2008, 20-21.
- *Convincing the Climate Change Skeptics*. The Boston Globe, August 4, 2008.[
- *Ending the Energy Stalemate: A Bipartisan Strategy To Meet America's Energy Challenges*. Presentation at the National Academies 2008 Energy Summit, Washington, D.C., March 14, 2008.
- *Global Climatic Disruption: Risks and Opportunities*. Presentation at Investor Summit on Climate Risk, New York, February 14, 2008.
- *Meeting the Climate-Change Challenge*. The John H. Chafee Memorial Lecture, National Council for Science and the Environment, Washington, D.C., January 17, 2008.

Figure 6.17: **John P. Holdren held the position of Assistant to the President for Science and Technology between 2009 and 2017.**

Figure 6.18: **John P. Holdren with Barack Obama.**

Figure 6.19: **John P. Holdren: "Trump has no science policy to speak of".**

6.15 Barry Commoner

Early life and education

Barry Commoner (1917-2012) was born in Brooklyn, New York, the son of Jewish immigrants from Russia. After a B.Sc. from Colombia University, he received a doctoral degree in cell biology from Harvard. In 1947, he became a professor of plant physiology at Washington University, Sr. Louis. and he taught there for the next 34 years.

A pioneer of ecology

While teaching at Washington University, Barry Commoner established the Center for the Biology of Natural Systems to study "the science of the total environment". During the late 1050's, Commoner's attention was drawn to health and environmental consequences of nuclear testing. His Baby Tooth Survey demonstrated that radioactive substances, such as Strontium 90, were being incorporated in the teeth of infants as a result of the testing of nuclear weapons. Commoner wrote: "The greatest single cause of environmental contamination of this planet is radioactivity from test explosions of nuclear weapons in the atmosphere."

Barry Commoner's US presidential campaign

In 1980, Barry Commoner founded the Citizens Party, and he ran as the party's candidate for the US presidency. Although he received only a very small percentage of the votes in the election, the campaign nevertheless made a wide public aware of the seriousness of ecological problems. During the last phase of his career, Commoner returned to New York as a professor at Queens College, part of the City University of New York. Although he stepped down from his professorship in 2000, he remained a senior scientist at Queens College until his death in 2012 at the age of 95.

Books and reports by Barry Commoner

- *Science and Survival* (1966), New York: Viking OCLC 225105 - on "the uses of science and technology in relation to environmental hazards".
- *The Closing Circle: Nature, Man, and Technology* (1971), New York: Knopf.
- *The Poverty of Power: Energy and the Economic Crisis* (1976), New York: Random House.
- *The Politics of Energy* (1979), New York: Knopf.
- *Making Peace With the Planet* (1990), New York: Pantheon.
- *Long-range Air Transport of Dioxin from North American Sources to Ecologically Vulnerable Receptors in Nunavut, Arctic Canada*, (2000), Commoner, Barry; Bartlett, Paul Woods; Eisl, Holger; Couchot, Kim; Center for the Biology of Natural Systems, Queens College, City University of New York, published by the North American Commission for Environmental Cooperation, MontrÃ©al, QuÃ©bec, Canada.

A few things that Barry Commoner said or wrote

The proper use of science is not to conquer nature but to live in it.

Everything is connected to everything else. Everything must go somewhere. Nature knows best. There is no such thing as a free lunch.

If you ask what you are going to do about global warming, the only rational answer is to change the way in which we do transportation, energy production, agriculture and a good deal of manufacturing. The problem originates in human activity in the form of the production of goods.

The environmental crisis is somber evidence of an insidious fraud hidden in the vaunted productivity and wealth of modern, technology-based society. This wealth has been gained by rapid short-term exploitation of the environmental system, but it has blindly accumulated a debt to nature - a debt so large and so pervasive that in the next generation it may, if unpaid, wipe out most of the wealth it has gained us.

Our assaults on the ecosystem are so powerful, so numerous, so finely interconnected, that although the damage they do is clear, it is very difficult to discover how it was done. By which weapon? In whose hand? Are we driving the ecosphere to destruction simply by our growing numbers? By our greedy accumulation of wealth? Or are the machines which we have built to gain this wealth-the magnificent technology that now feeds us out of neat packages, that clothes us in man-made fibers, that surrounds us with new chemical creations-at fault?

The environmental crisis arises from a fundamental fault: our systems of production - in industry, agriculture, energy and transportation - essential as they are, make people sick and die.

Sooner or later, wittingly or unwittingly, we must pay for every intrusion on the natural environment.

Air pollution is not merely a nuisance and a threat to health. It is a reminder that our most celebrated technological achievements - the automobile, the jet plane, the power plant, industry in general, and indeed the modern city itself - are, in the environment, failures.

All of the clean technologies are known, it's a question of simply applying them.

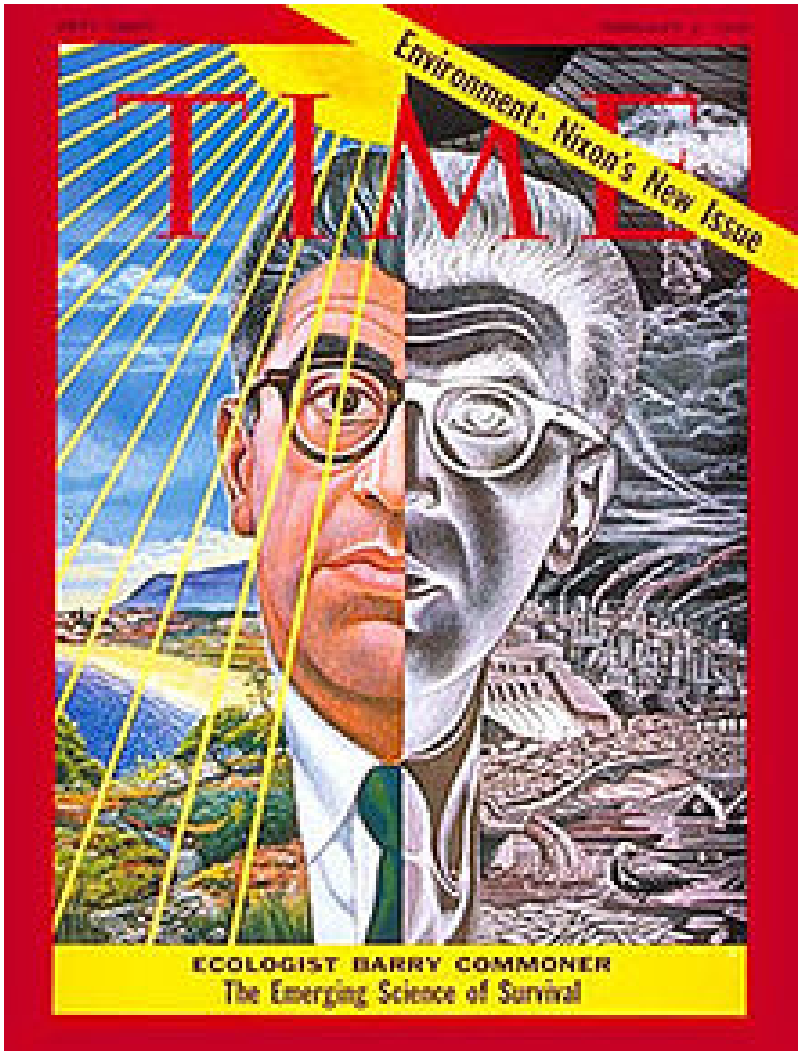


Figure 6.20: **Time reported in its February 1970 issue that "the national concern over the environment has reached an unprecedented level of intensity." On the cover, the visage of Barry Commoner projected a powerful image of ecology, which took the stage for the first time in the public eye.**

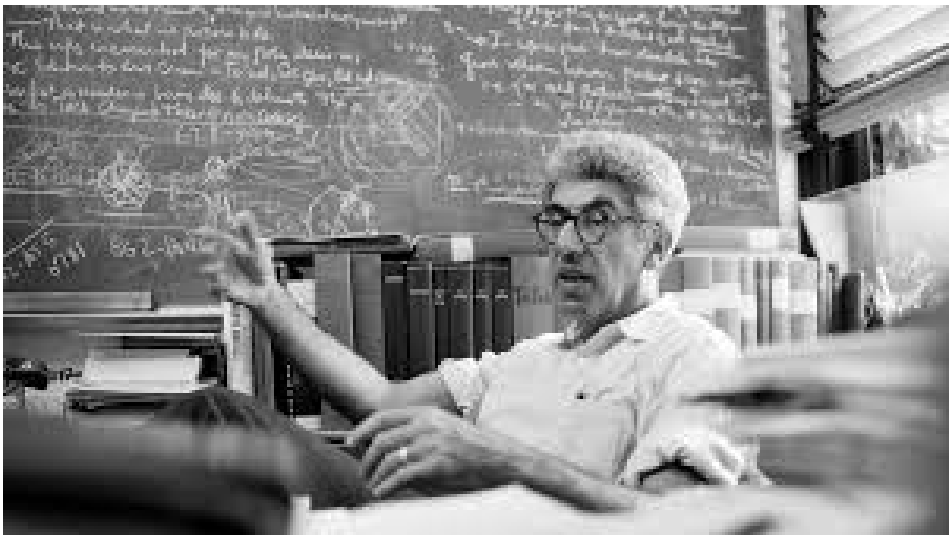
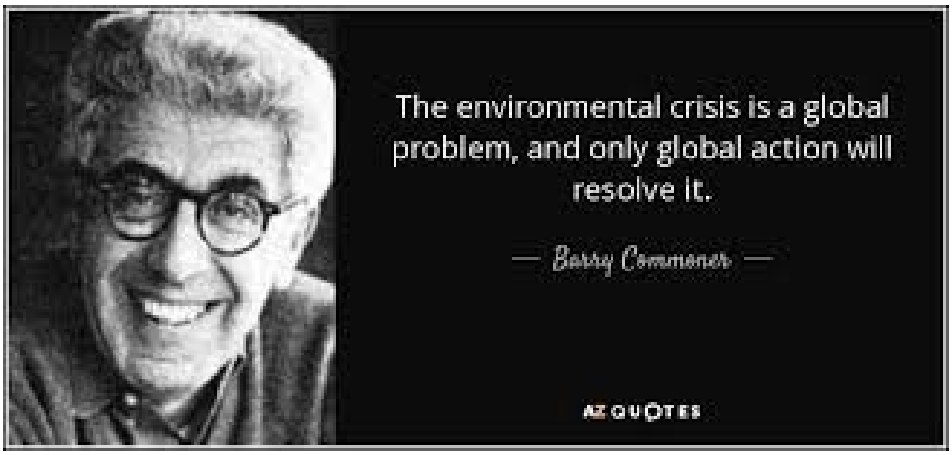


Figure 6.21: **Barry Commoner died at the age of 95 in 2012.**



The favorite statistic is that the U.S. contains 6 to 7% of the world population but consumes more than half the world's resources and is responsible for that fraction of the total environmental pollution. But this statistic hides another vital fact: that not everyone in the U.S. is so affluent.

Perhaps the simplest example is a synthetic plastic, which unlike natural materials, is not degraded by biological decay. It therefore persists as rubbish or is burned - in both cases causing pollution. In the same way, a substance such as DDT or lead, which plays no role in the chemistry of life and interferes with the actions of substances that do, is bound to cause ecological damage if sufficiently concentrated.

Because the global ecosystem is a connected whole, in which nothing can be gained or lost and which is not subject to over-all improvement, anything extracted from it by human effort must be replaced. Payment of this price cannot be avoided; it can only be delayed. The present environmental crisis is a warning that we have delayed nearly too long.

Despite the dazzling successes of modern technology and the unprecedented power of modern military systems, they suffer from a common and catastrophic fault. While providing us with a bountiful supply of food, with great industrial plants, with high-speed transportation, and with military weapons of unprecedented power, they threaten our very survival.

Suggestions for further reading

1. Rachel L. Carson *Under the Sea-Wind* Oxford University Press, 1952
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Chapter 7

THE DEEP STATE

7.1 Julian Assange, a martyr to the truth

The jaws of power are always open to devour, and her arm is always stretched out, if possible, to destroy the freedom of thinking, speaking, and writing. (John Adams, 1735-1826)

According to the Nuremberg Principles, the citizens of a country have a responsibility for the crimes that their governments commit. But to prevent these crimes, the people need to have some knowledge of what is going on. Indeed, democracy cannot function at all without this knowledge.

What are we to think when governments make every effort to keep their actions secret from their own citizens? We can only conclude that although they may call themselves democracies, such governments are in fact oligarchies or dictatorships.

At the end of World War I, it was realized that secret treaties had been responsible for its outbreak, and an effort was made to ensure that diplomacy would be more open in the future. Needless to say, these efforts did not succeed, and diplomacy has remained a realm of secrecy.

Many governments have agencies for performing undercover operations (usually very dirty ones). We can think, for example of the KGB, the CIA, M5, or Mossad. How can countries that have such agencies claim to be democracies, when the voters have no knowledge of or influence over the acts that are committed by the secret agencies of their governments?

Nuclear weapons were developed in secret. It is doubtful whether the people of the United States would have approved of the development of such antihuman weapons, or their use against an already-defeated Japan, if they had known that these things were going to happen. The true motive for the nuclear bombings was also kept secret. In the words of General Groves, speaking confidentially to colleagues at Los Alamos, the real motive was "to control the Soviet Union".

The true circumstances surrounding the start of the Vietnam war would never have

been known if Daniel Ellsberg had not leaked the Pentagon Papers. Ellsberg thought that once the American public realized that their country's entry into the war was based on a lie, the war would end. It did not end immediately, but undoubtedly Ellsberg's action contributed to the end of the war.

We do not know what will happen to Julian Assange. If his captors send him to the US, and if he is imprisoned for life there for the crime of publishing leaked documents (a crime that he shares with the New York Times), he will not be the first martyr to the truth.

The ageing Galileo was threatened with torture and forced to recant his heresy, that the Earth moves around the Sun. Galileo spent the remainder of his days in house arrest.

Giordano Bruno was less lucky. He was burned at the stake for maintaining that the universe is larger than it was then believed to be.

If Julian Assange becomes a martyr to the truth like Galileo or Bruno, his name will be honored in the future, and the shame of his captors will be remembered too.

Figure 7.1: **Assange speaks on the steps of St Paul's Cathedral in London, 16 October 2011.**

7.2 Edward Snowden's revelations

Can a government, many of whose operations are secret, be a democracy? Obviously this is impossible. The recent attempts of the United States to arrest whistleblower Edward Snowden call attention to the glaring contradiction between secrecy and democracy.

In a democracy, the power of judging and controlling governmental policy is supposed to be in the hands of the people. It is completely clear that if the people do not know what their government is doing, then they cannot judge or control governmental policy, and democracy has been abolished. There has always been a glaring contradiction between democracy and secret branches of the government, such as the CIA, which conducts its assassinations and its dirty wars in South America without any public knowledge or control.

The gross, wholesale electronic spying on citizens revealed by Snowden seems to be specifically aimed at eliminating democracy. It is aimed at instilling universal fear and conformity, fear of blackmail and fear of being out of step, so that the public will not dare to oppose whatever the government does, no matter how criminal or unconstitutional.

Henry Kissinger famously remarked: "The illegal we do at once. The unconstitutional takes a little longer". Well, Henry, that may have been true in your time, but today the unconstitutional does not take long at all.

The Magna Carta is trashed. No one dares to speak up. Habeas Corpus is trashed. No one dares to speak up. The United Nations Charter is trashed. No one dares to speak up. The Universal Declaration of Human Rights is trashed. No one dares to speak up. The Fourth Amendment to the US Constitution is trashed. No one dares to speak up. The President claims the right to kill both US and foreign citizens, at his own whim. No one dares to speak up.

But perhaps this is unjust. Perhaps some people would dare to protest, except that they cannot get their protests published in the mainstream media. We must remember that the media are owned by the same corporate oligarchs who own the government.

George Orwell, you should be living today! We need your voice today! After Snowden's revelations, the sale of Orwell's "1984" soared. It is now on the bestseller list. Sadly, Orwell's dystopian prophesy has proved to be accurate in every detail.

What is the excuse for for the massive spying reported by Snowden, spying not only on US citizens but also on the citizens of other countries throughout the world? "We want to protect you from terrorism.", the government answers. But terrorism is not a real threat, it is an invented one. It was invented by the military-industrial complex because, at the end of the Cold War, this enormous money-making conglomerate lacked enemies.

Globally, the number of people killed by terrorism is vanishingly small compared to the number of children who die from starvation every year. It is even vanishingly small compared with the number of people who are killed in automobile accidents. It is certainly small compared with the number of people killed in wars aimed at gaining western hegemony over oil-rich regions of the world.

But in Shelley's words, "We are many; they are few!" The people who want democracy greatly outnumber those who profit from maintaining a government based on secrecy and fear. Let us "rise like lions after slumbers, in unvanquishable numbers". Let us abolish

governmental secrecy and reclaim our democracy.

7.3 Secrecy and dark acts

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Figure 7.2: **The sales of George Orwell's 1984 soared after Snowden's revelations.**

Figure 7.3: **Susan Lindauer**

hegemony over oil-rich regions of the world.

In order to make the American people really fear terrorism, and in order to make them willing to give up their civil liberties, a big event was needed, something like the 9/11 attacks on the World Trade Center.

There is strong evidence, available on the Internet for anyone who wishes to look at it, that the US government knew well in advance that the 9/11 attacks would take place, and that government agents made the disaster worse than it otherwise would have been by planting explosives in the buildings of the World Trade Center. For example, CIA insider Susan Lindauer has testified that the US government knew about the planned attacks as early as April, 2001. Other experts have testified that explosives must have been used to bring the buildings down.

Numerous samples of the dust from the disaster were collected by people in New York City, and chemical analysis of the dust has shown the presence of nanothermite, a compound that produces intense heat. Pools of recently-melted steel were found in the ruins of the buildings before these were sealed off from the public. An ordinary fire does not produce temperatures high enough to melt steel.

Thus it seems probable that the US government participated in the 9/11 attacks, and used them in much the same way that the Nazis used the Reichstag fire, to abridge civil liberties and to justify a foreign invasion. Soon afterward, the Patriot Act was passed. It's Orwellian name is easily understood by anyone who has read "1984".

But in Shelley's words, "We are many; they are few!" The people who want democracy greatly outnumber those who profit from maintaining a government based on secrecy and fear. Let us "rise like lions after slumbers, in unvanquishable numbers". Let us abolish governmental secrecy and reclaim our democracy.

Governmental secrecy is not something new. Secret diplomacy contributed to the out-

break of World War I, and the secret Sykes-Picot agreement later contributed to the bitterness of conflicts in the Middle East. However, in recent years, governmental secrecy has grown enormously.

The revelations of Edward Snowden and others have shown that the number of people involved in secret operations of the United States government is now as large as the entire population of Norway: roughly 5 million. The influence of this dark side of government has become so great that no president is able to resist it.

In a recent article, John Chuckman remarked that "The CIA is now so firmly entrenched and so immensely well financed (much of it off the books, including everything from secret budget items to the peddling of drugs and weapons) that it is all but impossible for a president to oppose it the way Kennedy did. Obama, who has proved himself to be a fairly weak character from the start, certainly has given the CIA anything it wants. The dirty business of ISIS in Syria and Iraq is one project. The coup in Ukraine is another. The pushing of NATO's face right against Russia's borders is another. Several attempted coups in Venezuela are still more. And the creation of a drone air force for extra-judicial killings in half a dozen countries is yet another. They don't resemble projects we would expect from a smiley-faced intelligent man who sometimes wore sandals and refused to wear a flag pin on his lapel during his first election campaign." [1]

Of course the United States government is by no means alone in practicing excessive secrecy: Scott Horton recently wrote an article entitled *How to Rein in a Secretive Shadow Government Is Our National Security Crisis*. He dedicated the article to the Soviet dissident Andrei Sakharov because, as he said, "Sakharov recognized that the Soviet Union rested on a colossal false premise: it was not so much socialism (though Sakharov was certainly a critic of socialism) as it was the obsession with secrecy, which obstructed the search for truth, avoided the exposure of mistakes, and led to the rise of powerful bureaucratic elites who were at once incompetent and prone to violence."

[1] http://www.informationclearinghouse.info/article41222.htm

Figure 7.4: **The revelations of Edward Snowden and others have shown that the number of people involved in secret operations of the United States government is now as large as the entire population of Norway: roughly 5 million.**

Figure 7.5: **One of the power points used by NSA to sell their comprehensive collection of private data.**

Figure 7.6: **The data of major Internet corporations was stolen without their knowledge or consent.**

Figure 7.7: **These huge buildings in Fort Meade, Maryland, are the main headquarters of NSA.**

Figure 7.8: **Big Brother is watching you.**

7.4 *The United States of Secrets*

A review by Variety

Here are some excerpts from *Variety's* review of the first two parts of the series:

"Methodical and comprehensive, *Frontline's* documentary *The United States of Secrets* offers a blow-by-blow account of the Bush administration's embrace of potentially illegal spying/eavesdropping techniques, President Obama's decision to continue them (despite campaign promises to the contrary) and, most compellingly, those who sought to blow the whistle on government overreach, culminating with Edward Snowden's unprecedented dump of classified documents. If the two-part project breaks little new ground, it's an utterly thorough primer on what transpired that almost plays like a John Le Carre thriller, with remarkably candid interviews from participants on all sides...

"*United States of Secrets* also details the role played by the Fourth Estate, as frustrated officials reluctantly began going to the press, feeling they had no other recourse to beat back constitutional intrusions. Yet the New York Times, after nailing down the story, ultimately balked at running it, at the urging of the Bush administration..."

A review by Network Knowledge

Another review, by *Network Knowledge*, makes the following comments:

"WSEC/PBS Springfield will premiere a compelling two-part series entitled FRONTLINE - United States of Secrets. These programs go behind the headlines to reveal the dramatic story of how the U.S. government came to monitor and collect the communications of millions of people around the world - including ordinary Americans - and the lengths they went to trying to hide the massive surveillance program from the public.

"In part one, premiering Tuesday, May 13 at 8PM on WSEC/PBS Springfield, FRONTLINE filmmaker Michael Kirk goes inside Washington and the National Security Agency, piecing together the secret history of the unprecedented surveillance program that began in the wake of September 11 and continues today even after the revelations of its existence by NSA contractor Edward Snowden.

"Then, in part two, premiering Tuesday, May 20 at 9PM, veteran FRONTLINE filmmaker Martin Smith continues the story, exploring the secret relationship between Silicon Valley and the National Security Agency, and investigating how the government and tech companies have worked together to gather and warehouse your data.

"Part political thriller and part spy novel, United States of Secrets series is the definitive history of domestic surveillance in a post 9/11 world. With new revelations about government spying coming out almost daily, the series will be gripping viewing for those who want to understand the context of the Snowden affair and what it means for all Americans."

7.5 Censorship of the news

Many modern governments have become very expert in manipulating public opinion through mass media. They only allow the public to hear a version of the "news" that has been handed down by powerholders. Of course, people can turn to the alternative media that are available on the Internet. But on the whole, the vision of the world presented on television screens and in major newspapers is the "truth" that is accepted by the majority of the public, and it is this picture of events that influences political decisions. Censorship of the news by the power elite is a form of secrecy, since it withholds information that is needed for a democracy to function properly.

7.6 Coups, torture and illegal killing

During the period from 1945 to the present, the US interfered, militarily or covertly, in the internal affairs of a large number of nations: China, 1945-49; Italy, 1947-48; Greece, 1947-49; Philippines, 1946-53; South Korea, 1945-53; Albania, 1949-53; Germany, 1950s; Iran, 1953; Guatemala, 1953-1990s; Middle East, 1956-58; Indonesia, 1957-58; British Guiana/Guyana, 1953-64; Vietnam, 1950-73; Cambodia, 1955-73; The Congo/Zaire, 1960-65; Brazil, 1961-64; Dominican Republic, 1963-66; Cuba, 1959-present; Indonesia, 1965; Chile, 1964-73; Greece, 1964-74; East Timor, 1975-present; Nicaragua, 1978-89; Grenada, 1979-84; Libya, 1981-89; Panama, 1989; Iraq, 1990-present; Afghanistan 1979-92; El Salvador, 1980-92; Haiti, 1987-94; Yugoslavia, 1999; and Afghanistan, 2001-present, Syria, 2013-present; Egypt, 2013-present, and Ukraine, 2013-present. Most of these interventions were explained to the American people as being necessary to combat communism (or more recently, terrorism), but an underlying motive was undoubtedly the desire to put in place governments and laws that would be favorable to the economic interests of the US and its allies.

For the sake of balance, we should remember that during the Cold War period, the Soviet Union and China also intervened in the internal affairs of many countries, for example in Korea in 1950-53, Hungary in 1956, Czechoslovakia in 1968, and so on; another very long list. These Cold War interventions were also unjustifiable, like those mentioned above. Nothing can justify military or covert interference by superpowers in the internal affairs of smaller countries, since people have a right to live under governments of their own choosing even if those governments are not optimal.

Many people in Latin America and elsewhere have been tortured: The long history of CIA torture was recently investigated, but only small portions of the 6000-page report are available to the public. The rest remains secret.

Extrajudicial killing of civilians by means of drones is also shrouded by secrecy, and it too is a gross violation of democratic principles. [2]

[2] http://www.globalresearch.ca/lawless-drone-killings/5355535

7.7 Secret trade deals

The Trans-Pacific Partnership is one of the trade deals that is currently being negotiated in secret. Not even the US congress is allowed to know the details of the document. However, enough information has been leaked to make it clear that if the agreement is passed, foreign corporations would be allowed to "sue" the US government for loss of profits because of (for example) environmental regulations. The "trial" would be outside the legal system, before a tribunal of lawyers representing the corporations. A similar secret trade deal with Europe, the Trans-Atlantic Trade and Investment Partnership (TTIP), is also being "fast-tracked". One can hardly imagine greater violations of democratic principles.[3]

We can also consider the "non-discrimination" principle adopted by GATT (the General Agreement on Tariffs and Trade). This principle states that participating countries "cannot discriminate between like products on the basis of the method of production". This single principle allows multinational commerce to escape from all the humanitarian and environmental reforms that have been achieved since the start of the Industrial Revolution. No matter if the method of production involves destruction of a tropical rain forest, no matter if forced labor was used, we are not allowed to discriminate "on the basis of the method of production".

The present situation is that agriculture, trade and industry have become global, but the world still lacks adequate institutions at the global level to watch over what is happening and to ensure respect for human needs and respect for the natural environment. Today's global economic interdependence, instantaneous worldwide communication, and the need for peaceful resolution of international conflicts all call for strong governmental institutions at the global level, but the United Nations today lacks many things that would be necessary if it is to perform such a role: It lacks a legislature with the power to make laws binding on individuals and corporations. It lacks mechanisms for enforcing such laws. And it lacks a large and dependable source of income.

It would be logical to improve the United Nations by giving it the things just mentioned, and by giving it at the same time the task of regulating multinational corporations to ensure that they act in a socially and ecologically responsible manner. It would also be logical to entitle the UN to a fee for acting as a referee in relationships between multinationals and the developing countries. These reforms must come someday because of the logic of our present situation. I hope that they will come soon.

The CEO's of Wall Street call for less government, more deregulation and more globalization. They are delighted that the work of the reform movement is being undone in the name of "freedom". But is this really what is needed? We need instead to reform our economic system and to give it both a social conscience and an ecological conscience. Governments already accept their responsibility for education. In the future they must also accept the responsibility for ensuring that their citizens can make a smooth transition from

[3] http://www.citizen.org/Page.aspx?pid=5411
https://www.transcend.org/tms/2015/03/world-at-a-crossroads-stop-the-fast-track-to-a-future-of-global-corporate-rule/
http://talkingpointsmemo.com/livewire/princeton-experts-say-us-no- longer-democracy

education to secure jobs. The free market alone cannot do this the powers of government are needed. Let us restore democracy! Let us have governments that work for the welfare of all their citizens, rather than for the enormous enrichment of the few!

7.8 Secrecy, democracy and nuclear weapons

Nuclear weapons were developed in secret. The decision to use them on the civilian populations of Hiroshima and Nagasaki in an already-defeated Japan was made in secret. Since 1945, secrecy has surrounded all aspects of nuclear weapons, and for this reason it is clear that they are essentially undemocratic.

Nuclear disarmament has been one of the core aspirations of the international community since the first use of nuclear weapons in 1945. A nuclear war, even a limited one, would have global humanitarian and environmental consequences, and thus it is a responsibility of all governments, including those of non-nuclear countries, to protect their citizens and engage in processes leading to a world without nuclear weapons.

Now a new process has been established by the United Nations General Assembly, an Open Ended Working Group (OEWG) to Take Forward Multilateral Nuclear Disarmament Negotiations. The OEWG convened at the UN offices in Geneva on May 14, 2013. Among the topics discussed was a Model Nuclear Weapons Convention.

The Model Nuclear Weapons Convention prohibits development, testing, production, stockpiling, transfer, use and threat of use of nuclear weapons. States possessing nuclear weapons will be required to destroy their arsenals according to a series of phases. The Convention also prohibits the production of weapons usable fissile material and requires delivery vehicles to be destroyed or converted to make them non-nuclear capable.

Verification will include declarations and reports from States, routine inspections, challenge inspections, on-site sensors, satellite photography, radionuclide sampling and other remote sensors, information sharing with other organizations, and citizen reporting. Persons reporting suspected violations of the convention will be provided protection through the Convention including the right of asylum.

Thus we can see that the protection of whistleblowers is an integral feature of the Model Nuclear Weapons Convention now being discussed. As Sir Joseph Rotblat (1908-2005, Nobel Laureate 1995) frequently emphasized in his speeches, societal verification must be an integral part of the process of "going to zero" (i.e, the total elimination of nuclear weapons). This is because nuclear weapons are small enough to be easily hidden. How will we know whether a nation has destroyed all of its nuclear arsenal? We have to depend on information from insiders, whose loyalty to the whole of humanity prompts them to become whistleblowers. And for this to be possible, they need to be protected.

In general, if the world is ever to be free from the threat of complete destruction by modern weapons, we will need a new global ethic, an ethic as advanced as our technology. Of course we can continue to be loyal to our families, our localities and our countries. But this must be supplemented by a higher loyalty: a loyalty to humanity as a whole.

7.9 Freedom from fear

In order to justify secrecy, enormous dark branches of government and mass illegal spying, governments say: "We are protecting you from terrorism". But terrorism is not a real threat, since our chances of dying from a terrorist attack are vanishingly small compared to (for example) preventable disease or an automobile accident. If we are ever to reclaim our democracy, we must free ourselves from fear.

7.10 *Inside Job*

Peter Bradshaw's review in The Guardian

"If you're growing, you're not in recession ... right?" The speaker is Hank Paulson, the former US treasury secretary, and, as it happens, the former CEO of Goldman Sachs. In Charles Ferguson's documentary about the great financial crash, Paulson's shrugging remark sums up the attitude of the super-rich banking apparatchiks and their eager political supporters. As long as the bubble's getting bigger, there's no worry about the bubble contracting ... right? But that is not what happens to bubbles. In 2008, the pop was heard around the world.

This film is as gripping as any thriller. Aided by some fascinating interviews, Ferguson lays out an awful story. In the 1980s, the markets and financial services were deregulated, and the driving force for this liberalization was Alan Greenspan, formidable chairman of the US federal reserve board from 1987 to 2006. Banks and loan companies were freer to gamble with their depositors' money; they were themselves freer to borrow more; they were free to offer investors dizzyingly complex financial instruments, with income streams from different debts bundled up, including high-interest home loans offered to high-risk borrowers - the so-called "sub-prime" market that offered mouthwateringly high returns.

The good times rolled. The banks ballooned. They offered their traders mind-blowing bonuses to encourage risk-taking chutzpah, corporate loyalty, and a neurotically driven pursuit of profit. Ferguson argues that crucially, the banks were allowed to insure against bad debts with credit default swaps - any number of these insurance policies could be purchased against one particular risk. Chillingly, the banks now had a vested interest in selling insanely risky products, as they themselves were lavishly insured with these swaps.

Perhaps the most sensational aspect of this film is Ferguson's contention that the crash corrupted the discipline of economics itself. Distinguished economists from America's Ivy League universities were drafted in by banks to compose reports sycophantically supporting reckless deregulation. They were massively paid for these consultancies. The banks bought the prestige of the

academics, and their universities' prestige, too. Ferguson speaks to many of these economists, who clearly thought they were going to be interviewed as wry, dispassionate observers. It is really something to see the expression of shock, outrage and fear on their faces as they realize they're in the dock. One splutters with vexation; another gives vent to a ripe Freudian slip. Asked by Ferguson if he has any regrets about his behaviour, he says: "I have no comments ... uh, no regrets."

This is what Ferguson means by "inside job". There is a revolving door between the banks and the higher reaches of government, and to some extent the groves of academe. Bank CEOs become government officials, creating laws convenient for their once and future employers.

Perhaps only the pen of Tom Wolfe could do justice to these harassed, bald, middle-aged masters of the universe, as they appear in Ferguson's film. The director shows how their body-language is always the same: somehow more guilty-looking when they are in the White House rose garden in their career pomp, being introduced to the press, than when they are facing openly hostile Senate hearings. They look uneasy, shifty, in weirdly ill-fitting suits, as if they are oppressed by the scrutiny, and worn out, possibly, by the strain of suppressing their own scruples. Their financial capacity far outstrips their capacity for enjoying themselves. They look very unhappy. Occasionally, British figures including Mervyn King and Alistair Darling are to be glimpsed in these photos, reminding us that we Brits have been ardent deregulators, as well.

One of Ferguson's interviewees is Charles Morris, author of The Two Trillion Dollar Meltdown, who amusingly discusses the effects this mega-windfall has on the individual banker's mind. He became absurdly rich and "he thought it was because he was smart".

I was reminded of Michael Lewis's Liar's Poker, his very funny book about the financial mentality of the 80s boom. He noted that if a regular person won the lottery, he might roll around on the floor, kicking his legs up with glee, but when bankers won their arbitrary lottery, they instead became solemn, pompous, overwhelmed with their own importance and stateliness. Their recklessness and excess coexisted with an almost priestly sense of worth. Even more than rich lawyers, rich bankers felt that their money proved their superior cleverness and also moral worthiness as the generators of prosperity. Yet that prosperity didn't trickle down very far.

Generally, this is the sort of film that is praised because it is not as wacky and tricksy as Michael Moore. Yet it is clearly influenced by him - it's like a Moore film with the gags and stunts removed. And it's worth noting that without Moore's pioneering work, this documentary could not have been made.

Once again, the phrase that comes to mind is Milton Friedman's: socialism for the rich, free enterprise for the rest. An ordinary person defaults on his debt, he gets to live in his car. A banker defaults, and the taxpayer can be relied on to bail him out. No wonder the bonuses are back. But what can be done

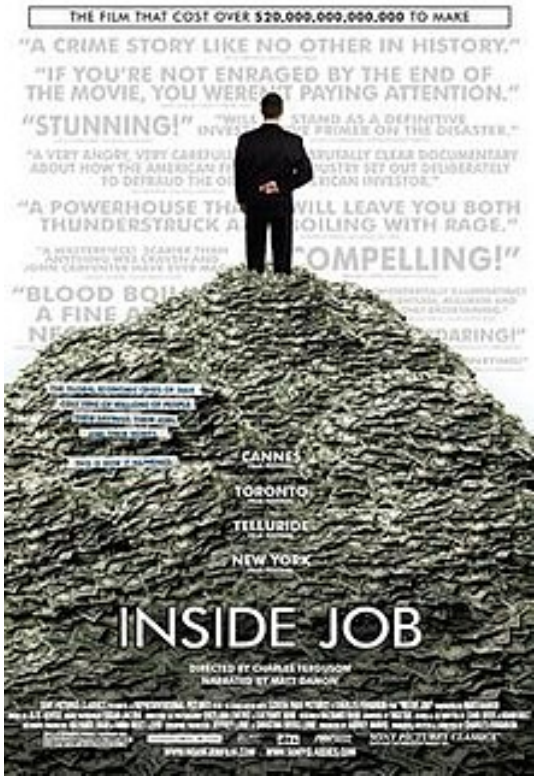

Figure 7.9: **A poster advertising the Academy-Award-winning documentary film *Inside Job*.**

about all this? Ferguson has no answers, other than a faintly unedifying hint that bankers could be brought low if rumours about their systemic addiction to drugs and prostitutes could be made to stick legally - like Al Capone's tax evasion. But only a new political mood for regulation will do, and this still seems far away.

Figure 7.10: **John Perkins was an economic hit man employed by the US Government. Image source: www.whale.to**

7.11 *Confessions of an economic hit-man*

A book by John Perkins, "Confessions of an Economic Hit-Man", can give us a good understanding of the way in which our present economic system operates to further enrich wealthy nations and impoverish poor ones. Here are some excerpts:

"Economic hit men (EHMs) are highly paid professionals who cheat countries around the globe out of trillions of dollars. They funnel money from the World Bank, the U.S. Agency for International Development (USAID), and other foreign 'aid' organizations into the coffers of huge corporations and the pockets of a few wealthy families who control the planet's natural resources."

"Their tools included fraudulent financial reports, rigged elections, payoffs, extortion, sex, and murder. They play a game as old as empire, but one that has taken on new and terrifying dimensions during this time of globalization. I was initially recruited while I was in business school back in the late sixties by the National Security Agency, the nation's largest and least understood spy organization; but ultimately I worked for private corporations."

"The first real economic hit man was back in the early 1950s, Kermit Roosevelt, Jr., the grandson of Teddy, who overthrew the government of Iran, a democratically elected government, Mossadegh's government, who was Time magazine's person of the year; and he was so successful at doing this without any bloodshed, well, there was a little bloodshed, but no military intervention, just spending millions of dollars and replaced Mossadegh with

the Shah of Iran."

"At that point, we understood that this idea of economic hit man was an extremely good one. We didn't have to worry about the threat of war with Russia when we did it this way. The problem with that was that Roosevelt was a C.I.A. agent. He was a government employee. Had he been caught, we would have been in a lot of trouble. It would have been very embarrassing. So, at that point, the decision was made to use organizations like the C.I.A. and the N.S.A. to recruit potential economic hit men like me and then send us to work for private consulting companies, engineering firms, construction companies, so that if we were caught, there would be no connection with the government."[4]

Suggestions for further reading

1. Marc Ambinder and D.B. Grady, *Deep State: Inside the Government Secrecy Industry*, Wiley, (2013).
2. Michael J. Glennon *National Security and Double Government* (PDF), Harvard National Security Journal. 5, (2014).
3. Jordan Michael Smith. *Vote all you want. The secret government won't change.* The Boston Globe,(October 19, 2014).
4. Amanda Taub and Max Fisher, *As Leaks Multiply, Fears of a 'Deep State' in America.* The New York Times, (February 16, 2017).
5. Bob Jessop,*The State: Past, Present, Future*, John Wiley & Sons, (2015).
6. Jeremy Scahill, *Donald Trump and the Coming Fall of the American Empire.* The Intercept, (2017-07-22).
7. Alana Abramson, *President Trump's Allies Keep Talking About the 'Deep State.' What's That?.* Time, (8 March 2017).
8. Ishaan Tharoor, *Is Trump fighting the deep state or creating his own?.* The Washington Post, (February 1, 2017).
9. Michael Crowley, *The Deep State Is Real.* Politico Magazine, (September-October 2017).
10. Julie Hirschfeld Davis, *Rumblings of a 'Deep State' Undermining Trump? It Was Once a Foreign Concept.* The New York Times, (March 6, 2017).

[4]http://techrig.blogspot.dk/2013/11/confessions-of-economic-hit-man.html
https://www.youtube.com/watch?v=yTbdnNgqfs8
https://en.wikipedia.org/wiki/Corporatocracy

Chapter 8

A NEW SOCIAL CONTRACT

8.1 Caring for the future of our children

Our present situation is this:

The future looks extremely dark because of human folly, especially the long-term future. The greatest threats are catastrophic climate change and thermonuclear war, but a large-scale global famine also has to be considered.

We give our children loving care, but it makes no sense do so and at the same time to neglect to do all that is within our power to ensure that they and their descendants will inherit an earth in which they can survive. We also have a responsibility to all the other living organisms with which we share the gift of life.

Inaction is not an option. We have to act with courage and dedication, even if the odds are against success, because the stakes are so high. The mass media could mobilize us to action, but they have failed in their duty. Our educational system could also wake us up and make us act, but it too has failed us. The battle to save the earth from human greed and folly has to be fought in the alternative media. Hence this book, and hence urgent the tone of this final chapter.

We need a new economic system, a new society, a new social contract, a new way of life. Here are the great tasks that history has given to our generation: We must achieve a steady-state economic system. We must restore democracy. We must decrease economic inequality. We must break the power of corporate greed. We must leave fossil fuels in the ground. We must stabilize and ultimately reduce the global population. We must eliminate the institution of war. And finally, we must develop a more mature ethical system to match our new technology.

8.2 We must achieve a steady-state economic system

A steady-state economic system is necessary because neither population growth nor economic growth can continue indefinitely on a finite earth. No one can maintain that exponential industrial growth is sustainable in the long run except by refusing to look more

Figure 8.1: **Nicholas Georgescu-Roegen: He showed that our present economic system is not cyclic but unidirectional, since it involves the irreversible degradation of non-renewable resources.**

than a short distance into the future.

Of course, it is necessary to distinguish between industrial growth, and growth of culture and knowledge, which can and should continue to grow. Qualitative improvements in human society are possible and desirable, but resource-using and pollution-producing industrial growth is reaching its limits, both because of ecological constraints and because of the exhaustion of petroleum, natural gas and other non-renewable resources, such as metals. The threat of catastrophic climate change makes it imperative for us to stop using fossil fuels within very few decades.

Our present economic system as unidirectional and entropic: Low-entropy resources are converted into high-entropy waste, a unidirectional process. By contrast, to be sustainable in the long run, a process must be cyclic, like the growth and regeneration of a forest.

Georgescu-Roegen's list of desiderata remains valid today: We need drastic cuts in weapons production, thereby releasing productive forces for more constructive purposes. We need immediate aid to underdeveloped countries and gradual decrease in population to a level that can be maintained by organic agriculture. We also need avoidance, and strict regulation if necessary, of wasteful energy use. Finally, we need to abandon our attachment to extravagant gadgetry and fashion, and we must cure ourselves of workaholic habits by re-balancing the time spent on work and leisure.

Today, the distinguished economist Herman Daly (a student of Georgescu-Roegen) continues to write perceptive articles and books documenting the need for a steady-state economy. Among his books, the following are noteworthy: "Steady-State Economics" (1977); "For the Common Good" (1989, with John B. Cobb, Jr.); "Valuing the Earth" (1993, with Kenneth Townsend); "Beyond Growth" (1996); "Ecological Economics and the Ecology of Economics" (1999); "Local Politics of Global Sustainability" (2000, with Thomas Prugh and Robert Costanza), and "Ecological Economics: Principles and Applications" (2003,

Figure 8.2: **Herman E. Daly: A student of Georgescu-Roegen the distinguished economist, Prof. H.E. Daly calls for a transition to a steady-state economic system, in which processes would be cyclic and sustainable.**

with Joshua Farley.[1]

[1]http://steadystate.org/category/herman-daly/
https://en.wikipedia.org/wiki/Herman_Daly
http://grist.org/article/bank/
http://www.donellameadows.org/wp-content/userfiles/Limits-to-Growth-digital-scan-version.pdf
http://www.clubofrome.org/?p=326

8.3 We must restore democracy

It is obvious, almost by definition, that excessive governmental secrecy and true democracy are incompatible. If the people of a country have no idea what their government is doing, they cannot possibly have the influence on decisions that the word "democracy" implies.

Governmental secrecy is not something new. Secret diplomacy contributed to the outbreak of World War I, and the secret Sykes-Picot Agreement later contributed to the bitterness of conflicts in the Middle East. However, in recent years, governmental secrecy has grown enormously.

The revelations of Edward Snowden have shown that the number of people involved in secret operations of the United States government is now as large as the entire population of Norway: roughly 5 million. The influence of this dark side of government has become so great that no president is able to resist it.

Many modern governments have become very expert in manipulating public opinion through mass media. They only allow the public to hear a version of the "news" that has been handed down by powerholders. Of course, people can turn to the alternative media that are available on the Internet. But on the whole, the vision of the world presented on television screens and in major newspapers is the "truth" that is accepted by the majority of the public, and it is this picture of events that influences political decisions. Censorship of the news by the power elite is a form of secrecy, since it withholds information that is needed for a democracy to function properly.

Snowden has already said most of what he has to say. Nevertheless, Washington was willing to break international law and the rules of diplomatic immunity by forcing its European allies to ground the plane of Bolivian President Evo Morales following a rumor that Snowden was on board. This was not done to prevent Snowden from saying more, but with the intention of making a gruesome example of him, as a warning to other whistleblowers.

In a democracy, the power of judging and controlling governmental policy is supposed to be in the hands of the people. It is completely clear that if the people do not know what their government is doing, then they cannot judge or control governmental policy, and democracy has been abolished. There has always been a glaring contradiction between democracy and secret branches of the government, such as the CIA, which conducts its assassinations and its dirty wars in South America and elsewhere without any public knowledge or control.

The gross, wholesale electronic spying on citizens revealed by Snowden seems to be specifically aimed at eliminating democracy. It is aimed at instilling universal fear and conformity, fear of blackmail and fear of being out of step, so that the public will not dare to oppose whatever the government does, no matter how criminal or unconstitutional.

We must restore democracy wherever it has been replaced by oligarchy. When we do so, we will free ourselves from many evils, including excessive economic inequality, violation of civil rights, and the suffering produced by perpetual wars.

Figure 8.3: **Edward Snowden.**

8.4 We must decrease economic inequality

In his Apostolic Exhortation, "Evangelii Gaudium", Pope Francis said: "In our time humanity is experiencing a turning-point in its history, as we can see from the advances being made in so many fields. We can only praise the steps being taken to improve people's welfare in areas such as health care, education and communications. At the same time we have to remember that the majority of our contemporaries are barely living from day to day, with dire consequences. A number of diseases are spreading. The hearts of many people are gripped by fear and desperation, even in the so-called rich countries. The joy of living frequently fades, lack of respect for others and violence are on the rise, and inequality is increasingly evident. It is a struggle to live and, often, to live with precious little dignity."

"This epochal change has been set in motion by the enormous qualitative, quantitative, rapid and cumulative advances occurring in the sciences and in technology, and by their instant application in different areas of nature and of life. We are in an age of knowledge and information, which has led to new and often anonymous kinds of power."

Figure 8.4: **We must decrease economic inequality.**

"Just as the commandment 'Thou shalt not kill' sets a clear limit in order to safeguard the value of human life, today we also have to say 'thou shalt not' to an economy of exclusion and inequality. Such an economy kills. How can it be that it is not a news item when an elderly homeless person dies of exposure, but it is news when the stock market loses two points? This is a case of exclusion. Can we continue to stand by when food is thrown away while people are starving? This is a case of inequality. Today everything comes under the laws of competition and the survival of the fittest, where the powerful feed upon the powerless. As a consequence, masses of people find themselves excluded and marginalized: without work, without possibilities, without any means of escape."

"In this context, some people continue to defend trickle-down theories which assume that economic growth, encouraged by a free market, will inevitably succeed in bringing about greater justice and inclusiveness in the world. This opinion, which has never been confirmed by the facts, expresses a crude and naive trust in the goodness of those wielding economic power and in the sacralized workings of the prevailing economic system. Meanwhile, the excluded are still waiting."

In a recent speech, Senator Bernie Sanders quoted Pope Francis extensively and added: "We have a situation today, Mr. President, incredible as it may sound, where the wealthiest 85 people in the world own more wealth than the bottom half of the world's population."[2]

The social epidemiologist Prof. Richard Wilkinson, has documented the ways in which societies with less economic inequality do better than more unequal societies in a number of areas, including increased rates of life expectancy, mathematical performance, literacy, trust, social mobility, together with decreased rates of infant mortality, homicides, imprisonment, teenage births, obesity and mental illness, including drug and alcohol addiction.[3] We must also remember that according to the economist John A. Hobson, the basic problem that led to imperialism was an excessively unequal distribution of incomes in the industrialized countries. The result of this unequal distribution was that neither the rich nor the poor could buy back the total output of their society. The incomes of the poor were insufficient, and rich were too few in number.

8.5 We must break the power of corporate greed

When the United Nations was established in 1945, the purpose of the organization was to abolish the institution of war. This goal was built into many of the articles of the UN Charter. Accordingly, throughout the world, many War Departments were renamed and became Departments of Defense. But the very name is a lie. In an age of nuclear threats

[2]https://www.youtube.com/watch?v=9_LJpN893Vg
https://www.oxfam.org/en/tags/inequality
https://www.oxfam.org/sites/www.oxfam.org/files/file_attachments/cr-even-it-up-extreme-inequality-291014-en.pdf

[3]https://www.youtube.com/watch?v=cZ7LzE3u7Bw
https://en.wikipedia.org/wiki/Richard_G._Wilkinson

and counter-threats, populations are by no means protected. Ordinary citizens are just hostages in a game for power and money. It is all about greed.

Why is war continually threatened? Why is Russia threatened? Why is war with Iran threatened? Why fan the flames of conflict with China? Is it to "protect" civilians? Absolutely not! In a thermonuclear war, hundreds of millions of civilians would die horribly everywhere in the world, also in neutral countries. What is really being protected are the profits of arms manufacturers. As long as there are tensions; as long as there is a threat of war, military budgets are safe; and the profits of arms makers are safe. The people in several "democracies", for example the United States, do not rule at the moment. Greed rules.

As Institute Professor Noam Chomsky of MIT has pointed out, greed and lack of ethics are built into the structure of corporations. By law, the Chief Executive Officer of a corporation must be entirely motivated by the collective greed of the stockholders. He must maximize profits. If the CEO abandons this single-minded chase after corporate profits for ethical reasons, or for the sake of humanity or the biosphere or the future, he (or she) must, by law, be fired and replaced.

Occasionally, for the sake of their public image, corporations seem to do something for other motives than their own bottom line, but it is usually window dressing. For example, Shell claims to be supporting research on renewable energy. Perhaps there is indeed a small renewable energy laboratory somewhere in that vast corporation; but the real interest of the organization is somewhere else. Shell is sending equipment on a large scale to drill for more and more environment-destroying oil in the Arctic.[4]

[4]http://www.countercurrents.org/avery170715.htm
http://human-wrongs-watch.net/2015/06/25/militarisms-hostages/
https://www.youtube.com/watch?v=FJUA4cm0Rck

Figure 8.5: **We must break the power of corporate greed.**

Figure 8.6: **Greed is driving us towards disaster.**

8.6 We must leave fossil fuels in the ground

The threat of catastrophic climate change requires prompt and dedicated action by the global community. Unless we very quickly make the transition from fossil fuels to 100% renewable energy, we will reach a tipping point after which uncontrollable feedback loops could take over, leading to a human-caused 6th geological extinction event. This might even be comparable to the Permian-Triassic event, during which 96% of all marine species and 70% of terrestrial vertebrates became extinct.

New hope that such a catastrophe for human civilization and the biosphere can be avoided comes from two recently-released documents: The Encyclical "Laudato Si' " by Pope Francis, and the statistics on the rate of growth of renewable energy newly released by the Earth Policy Institute.

Arctic sea-ice is melting at an increasingly rapid rate, because of several feedback loops. One of these feedback loops, called the albedo effect, is due to the fact that white snow-covered sea-ice in the Arctic reflects sunlight, while dark water absorbs it, raising the temperature and leading to more melting.

Another feedback loop is due to the fact that rising temperatures mean that more water is evaporated. The water vapor in the atmosphere acts like a greenhouse gas, and raises the temperature still further.

If we consider long-term effects, by far the most dangerous of the feedback loops is the melting of methane hydrate crystals and the release of methane into the atmosphere, where its effects as a greenhouse gas are roughly twenty times great as those of CO_2.

When organic matter is carried into the oceans by rivers, it decays to form methane. The methane then combines with water to form hydrate crystals, which are stable at the

temperatures which currently exist on ocean floors. However, if the temperature rises, the crystals become unstable, and methane gas bubbles up to the surface.

The worrying thing about methane hydrate deposits on ocean floors is the enormous amount of carbon involved: roughly 10,000 gigatons. To put this huge amount into perspective, we can remember that the total amount in world CO_2 emissions since 1751 has been only 337 gigatons.

Despite the worrying nature of the threats that we are facing, there are reasons for hope. One of the greatest of these is the beautiful, profound and powerful encyclical that has just been released by Pope Francis.[5]

Pope Francis tells us that the dictates of today's economists are not sacred: In the future, if we are to survive, economics must be given both a social conscience and an ecological conscience. Nor are private property and profits sacred. They must be subordinated to the common good, and the preservation of our global commons. Less focus on material goods need not make us less happy. The quality of our lives can be increased, not decreased, if we give up our restless chase after power and wealth, and derive more of our pleasures from art, music and literature, and from conversations with our families and friends.

Another reason for hope can be found in the extremely high present rate of growth of renewable energy, and in the remarkable properties of exponential growth. According to figures recently released by the Earth Policy Institute,[6] the global installed photovoltaic capacity is currently able to deliver 242,000 megawatts, and it is increasing at the rate of 27.8% per year. Wind energy can now deliver 370,000 megawatts, and it is increasing at the rate of roughly 20% per year.

Because of the astonishing properties of exponential growth, we can calculate that if these growth rates are maintained, renewable energy can give us 24.8 terawatts within only 15 years! This is far more than the world's present use of all forms of energy.

All of us must still work with dedication to provide the political will needed to avoid catastrophic climate change. However, the strong and friendly voice of Pope Francis, and the remarkable rate of growth of renewable energy can guide our work, and can give us hope and courage.

The award-winning author and activist Naomi Klein has emphasized that the climate crisis changes everything. Environmentalists and antiwar activists must unite! We need a new economic system! The people of the world don't want climate change; they want system change![7]

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[5] http://w2.vatican.va/content/francesco/en/encyclicals/documents
/papa -francesco_20150524_enciclica-laudato-si.html

[6] http://www.earth-policy.org/books/tgt

[7] https://www.transcend.org/tms/2015/03/naomi-klein-the-economic-system-we-have-created-global-warming/
http://thischangeseverything.org/naomi-klein/
http://eruditio.worldacademy.org/issue-5/article/urgent-need-renewable-energy
http://www.worldbank.org/en/news/feature/2012/11/18/Climate-change-report-warns-dramatically-warmer-world-this-century
https://www.youtube.com/watch?v=sRGVTK-AAvw

8.7 We must stabilize, and ultimately reduce, global population

According to the World Resources Institute and the United Nations Environment Programme, "It is estimated that since World War II, 1.2 billion hectares...[of agricultural land] has suffered at least moderate degradation as a result of human activity. This is a vast area, roughly the size of China and India combined." This area is 27% of the total area currently devoted to agriculture 5 . The report goes on to say that the degradation is greatest in Africa.

David Pimental and his associates at Cornell University pointed out in 1995 that "Because of erosion-associated loss of productivity and population growth, the per capita food supply has been reduced over the past 10 years and continues to fall. The Food and Agricultural Organization reports that the per capita production of grains which make up 80% of the world's food supply, has been declining since 1984."

Pimental et al. add that "Not only is the availability of cropland per capita decreasing as the world population grows, but arable land is being lost due to excessive pressure on the environment. For instance, during the past 40 years nearly one-third of the world's cropland (1.5 billion hectares) has been abandoned because of soil erosion and degradation. Most of the replacement has come from marginal land made available by removing forests. Agriculture accounts for 80% of the annual deforestation."

The phrase "developing countries" is more than a euphemism; it expresses the hope that with the help of a transfer of technology from the industrialized nations, all parts of the world can achieve prosperity. An important factor that prevents the achievement of worldwide prosperity is population growth.

In the words of Dr. Halfdan Mahler, former Director General of the World Health Organization, "Country after country has seen painfully achieved increases in total output, food production, health and educational facilities and employment opportunities reduced or nullified by excessive population growth."

The growth of population is linked to excessive urbanization, infrastructure failures and unemployment. In rural districts in the developing countries, family farms are often divided among a growing number of heirs until they can no longer be subdivided. Those family members who are no longer needed on the land have no alternative except migration to overcrowded cities, where the infrastructure is unable to cope so many new arrivals. Often the new migrants are forced to live in excrement-filled makeshift slums, where dysentery, hepatitis and typhoid are endemic, and where the conditions for human life sink to the lowest imaginable level. In Brazil, such shanty towns are called "favelas".

If modern farming methods are introduced in rural areas while population growth con-

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https://www.youtube.com/watch?v=MVwmi7HCmSI
https://www.youtube.com/watch?v=AjZaFjXfLec
https://www.youtube.com/watch?v=m6pFDu7lLV4
https://www.youtube.com/watch?v=MVwmi7HCmSI
http://therightsofnature.org/universal-declaration/

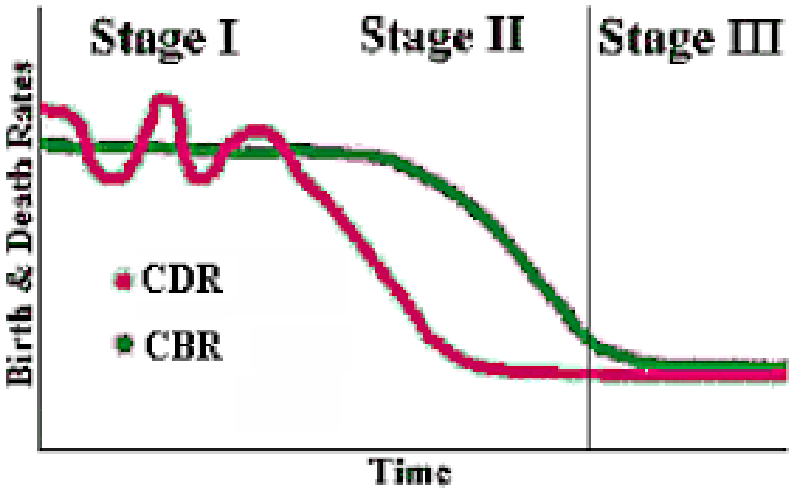


Figure 8.7: **We must stabilize, and ultimately reduce, global population. If we are to avoid a large-scale famine, all countries must pass through the demographic transition.**

tinues, the exodus to cities is aggravated, since modern techniques are less labor-intensive and favor large farms. In cities, the development of adequate infrastructure requires time, and it becomes a hopeless task if populations are growing rapidly. Thus, population stabilization is a necessary first step for development.

It can be observed that birth rates fall as countries develop. However, development is sometimes blocked by the same high birth rates that economic progress might have prevented. In this situation (known as the "demographic trap"), economic gains disappear immediately because of the demands of an exploding population.

For countries caught in the demographic trap, government birth control programs are especially important, because one cannot rely on improved social conditions to slow birth rates. Since health and lowered birth rates should be linked, it is appropriate that family-planning should be an important part of programs for public health and economic development.

A recent study conducted by Robert F. Lapham of Demographic Health Surveys and W. Parker Maudlin of the Rockefeller Foundation has shown that the use of birth control is correlated both with socio-economic setting and with the existence of strong family-planning programs. The implication of this study is that even in the absence of increased living standards, family planning programs can be successful, provided they have strong government support.

Education of women and higher status for women are vitally important measures, not only for their own sake, but also because in many countries these social reforms have proved to be the key to lower birth rates. As Sir Partha Dasgupta of Cambridge University has pointed out, the changes needed to break the cycle of overpopulation and poverty are all desirable in themselves. Besides education and higher status for women, they

include state-provided social security for old people, provision of water supplies near to dwellings, provision of health services to all, abolition of child labor and general economic development. The money required to make these desirable changes is a tiny fraction of the amount that is currently wasted on war.

In order to avoid a catastrophic future famine, it is vitally important that all of the countries of the world should quickly pass through a demographic transition from a situation characterized by high birth rates and high death rates to a new equilibrium, where low death rates are balanced by low birth rates.

8.8 We must eliminate the institution of war

The problem of achieving internal peace over a large geographical area is not insoluble. It has already been solved. There exist today many nations or regions within each of which there is internal peace, and some of these are so large that they are almost worlds in themselves. One thinks of China, India, Brazil, Australia, the Russian Federation, the United States, and the European Union. Many of these enormous societies contain a variety of ethnic groups, a variety of religions and a variety of languages, as well as striking contrasts between wealth and poverty. If these great land areas have been forged into peaceful and cooperative societies, cannot the same methods of government be applied globally?

But what are the methods that nations use to achieve internal peace? Firstly, every true government needs to have the power to make and enforce laws that are binding on individual citizens. Secondly the power of taxation is a necessity. Thirdly, within their own territories, almost all nations have more military power than any of their subunits. For example, the US Army is more powerful than the State Militia of Illinois.

This unbalance of power contributes to the stability of the Federal Government of the United States. When the FBI wanted to arrest Al Capone, it did not have to bomb Chicago. Agents just went into the city and arrested the gangster. Even if Capone had been enormously popular in Illinois, the the government of the state would have realized in advance that it had no chance of resisting the US Federal Government, and it still would have allowed the "Feds" to make their arrest. Similar considerations hold for almost all nations within which there is internal peace. It is true that there are some nations within which subnational groups have more power than the national government, but these are frequently characterized by civil wars.

Of the large land areas within which internal peace has been achieved, the European Union differs from the others because its member states still maintain powerful armies. The EU forms a realistic model for what can be achieved globally in the near future by reforming and strengthening the United Nations. In the distant future, however, we can imagine a time when a world federal authority will have much more power than any of its member states, and when national armies will have only the size needed to maintain local order.

Today there is a pressing need to enlarge the size of the political unit from the nation-

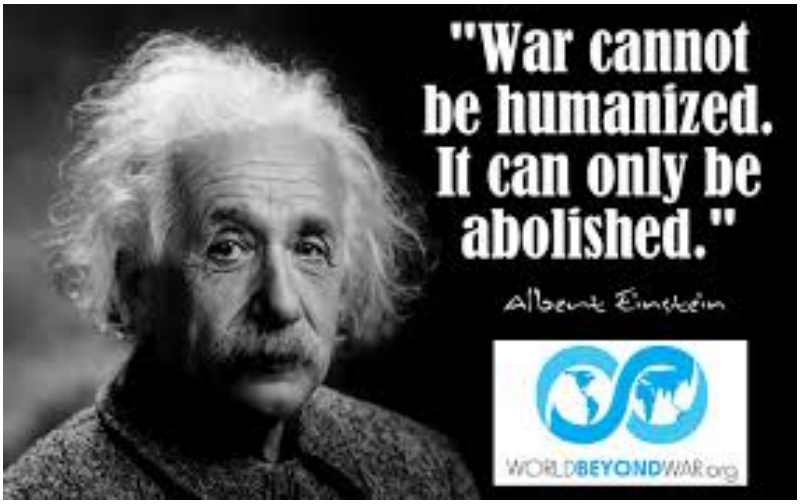


Figure 8.8: **We must abolish the institution of war.**

state to the entire world. The need to do so results from the terrible dangers of modern weapons and from global economic interdependence. The progress of science has created this need, but science has also given us the means to enlarge the political unit: Our almost miraculous modern communications media, if properly used, have the power to weld all of humankind into a single supportive and cooperative society.

8.9 Educational reforms

Educational reforms are urgently needed, particularly in the teaching of history. As it is taught today, history is a chronicle of power struggles and war, told from a biased national standpoint. Our own race or religion is superior; our own country is always heroic and in the right.

We urgently need to replace this indoctrination in chauvinism by a reformed view of history, where the slow development of human culture is described, giving adequate credit to all those who have contributed. Our modern civilization is built on the achievements of ancient cultures. China, India, Mesopotamia, ancient Egypt, Greece, the Islamic world, Christian Europe, and Jewish intellectual traditions all have contributed. Potatoes, corn and squash are gifts from the American Indians. Human culture, gradually built up over thousands of years by the patient work of millions of hands and minds, should be presented to students of history as a precious heritage - far too precious to be risked in a thermonuclear war.

In the teaching of science too, reforms are needed. Graduates in science and technology should be conscious of their responsibilities. They must resolve never to use their education in the service of war, or in any way which might be harmful to society or to the environment.

In modern societies, mass media play an extremely important role in determining be-

havior and attitudes. This role can be a negative one when the media show violence and enemy images, but if used constructively, the mass media can offer a powerful means for creating international understanding. If it is indeed true that tribalism is part of human nature, it is extremely important that the mass media be used to the utmost to overcome the barriers between nations and cultures. Through increased communication, the world's peoples can learn to accept each other as members of a single family.

Finally, let us turn to religion, with its enormous influence on human thought and behavior. Christianity, for example, offers a strongly stated ethic, which, if practiced, would make war impossible. In Mathew, the following passage occurs: "Ye have heard it said: Thou shalt love thy neighbor and hate thy enemy. But I say unto you: Love your enemies, bless them that curse you, do good to them that hate you, and pray for them that spitefully use you and persecute you."

This seemingly impractical advice, that we should love our enemies, is in fact of the greatest practicality, since acts of unilateral kindness and generosity can stop escalatory cycles of revenge and counter-revenge such as those which characterize the present conflict in the Middle East and the recent troubles of Northern Ireland. However, Christian nations, while claiming to adhere to the ethic of love and forgiveness, have adopted a policy of "massive retaliation", involving systems of thermonuclear missiles whose purpose is to destroy as much as possible of the country at which the retaliation is aimed. It is planned that entire populations shall be killed in a "massive retaliation", innocent children along with the guilty politicians. The startling contradiction between what the Christian nations profess and what they do was obvious even before the advent of nuclear weapons, at the time when Leo Tolstoy, during his last years, was exchanging letters with a young Indian lawyer in South Africa. In one of his letters to Gandhi, Tolstoy wrote:

"...The whole life of the Christian peoples is a continuous contradiction between that which they profess and the principles on which they order their lives, a contradiction between love accepted as the law of life, and violence, which is recognized and praised, acknowledged even as a necessity..."

"This year, in the spring, at a Scripture examination at a girls' high school in Moscow, the teacher and the bishop present asked the girls questions on the Commandments, and especially on the sixth. After a correct answer, the bishop generally put another question, whether murder was always in all cases forbidden by God's law; and the unhappy young ladies were forced by previous instruction to answer 'Not always' - that murder was permitted in war and in the execution of criminals. Still, when one of these unfortunate young ladies (what I am telling is not an invention but a fact told to me by an eye witness) after her first answer, was asked the usual question, if killing was always sinful, she, agitated and blushing, decisively answered 'Always', and to the usual sophisms of the bishop, she answered with decided conviction that killing was always forbidden in the Old Testament and forbidden by Christ, not only killing but every wrong against a brother. Notwithstanding all his grandeur and arts of speech, the bishop became silent and the girl remained victorious."

As everyone knows, Gandhi successfully applied the principle of non-violence to the civil rights struggle in South Africa, and later to the political movement, which gave India

its freedom and independence. The principle of non-violence was also successfully applied by Martin Luther King, and by Nelson Mandela. It is perhaps worthwhile to consider Gandhi's comment on the question of whether the end justifies the means: "The means may be likened to a seed", Gandhi wrote, "and the end to a tree; and there is the same inviolable connection between the means and the end as there is between the seed and the tree." In other words, a dirty method produces a dirty result; killing produces more killing; hate leads to more hate. Everyone who reads the newspapers knows that this is true. But there are positive feedback loops as well as negative ones. A kind act produces a kind response; a generous gesture is returned; hospitality results in reflected hospitality. Buddhists call this principle of reciprocity "the law of karma".

The religious leaders of the world have the opportunity to contribute importantly to the solution of the problem of war. They have the opportunity to powerfully support the concept of universal human brotherhood, to build bridges between religious groups, to make intermarriage across ethnic boundaries easier, and to soften the distinctions between communities. If they fail to do this, they will have failed humankind at a time of crisis.

It is useful to consider the analogy between the institution of war and the institution of slavery. We might be tempted to say, "There has always been war, throughout human history; and war will always continue to exist." As an antidote for this kind of pessimism, we can think of slavery, which, like war, has existed throughout most of recorded history. The cultures of ancient Egypt, Greece and Rome were all based on slavery, and, in more recent times, 13 million Africans were captured and forced into a life of slavery in the New World. Slavery was as much an accepted and established institution as war is today. Many people made large profits from slavery, just as arms manufacturers today make enormous profits. Nevertheless, in spite of the weight of vested interests, slavery has now been abolished throughout most of the world.

Today we look with horror at drawings of slave ships, where human beings were packed together like cord-wood; and we are amazed that such cruelty could have been possible. Can we not hope for a time when our descendants, reading descriptions of the wars of the twentieth century, will be equally amazed that such cruelty could have been possible? If we use them constructively, the vast resources now wasted on war can initiate a new era of happiness and prosperity for the Family of man. It is within our power to let this happen. The example of the men and women who worked to rid the world of slavery can give us courage as we strive for a time when war will exist only as a dark memory fading into the past.

8.10 Culture, education and human solidarity

Cultural and educational activities have a small ecological footprint, and therefore are more sustainable than pollution-producing, fossil-fuel-using jobs in industry. Furthermore, since culture and knowledge are shared among all nations, work in culture and education leads societies naturally towards internationalism and peace.

Economies based on a high level of consumption of material goods are unsustainable

and will have to be abandoned by a future world that renounces the use of fossil fuels in order to avoid catastrophic climate change, a world where non-renewable resources such as metals will become increasingly rare and expensive. How then can full employment be maintained?

The creation of renewable energy infrastructure will provide work for a large number of people; but in addition, sustainable economies of the future will need to shift many workers from jobs in industry to jobs in the service sector. Within the service sector, jobs in culture and education are particularly valuable because they will help to avoid the disastrous wars that are currently producing enormous human suffering and millions of refugees, wars that threaten to escalate into an all-destroying global thermonuclear war.[8]

Human nature has two sides: It has a dark side, to which nationalism and militarism appeal; but our species also has a genius for cooperation, which we can see in the growth of culture. Our modern civilization has been built up by means of a worldwide exchange of ideas and inventions. It is built on the achievements of many ancient cultures. China, Japan, India, Mesopotamia, Egypt, Greece, the Islamic world, Christian Europe, and the Jewish intellectual traditions all have contributed. Potatoes, corn, squash, vanilla, chocolate, chilli peppers, and quinine are gifts from the American Indians.[9]

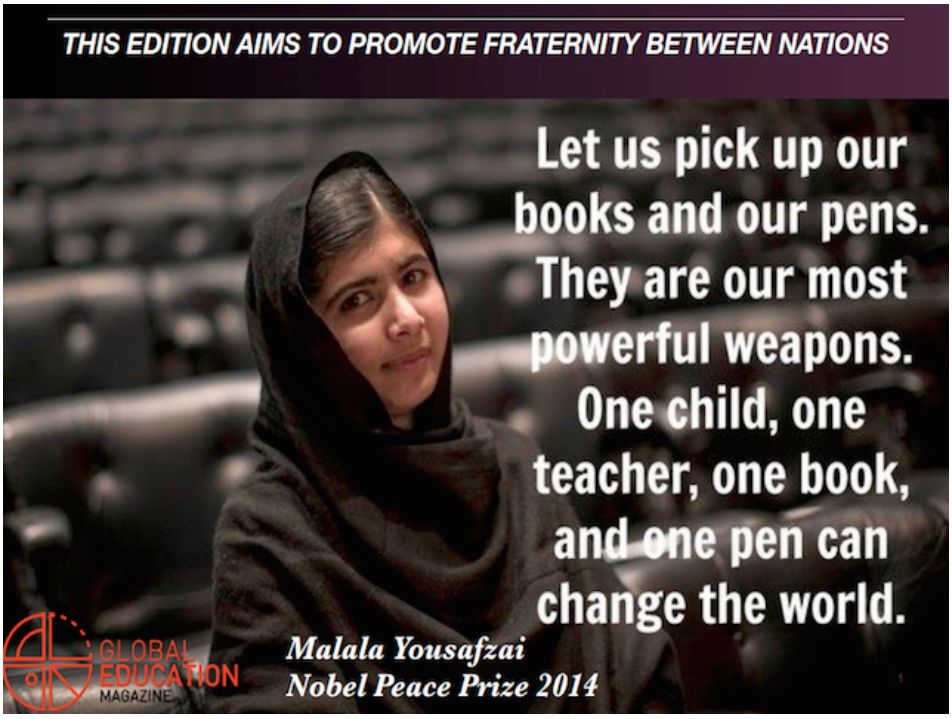
We need to reform our educational systems, particularly the teaching of history. As it is taught today, history is a chronicle of power struggles and war, told from a biased national standpoint. We are taught that our own country is always heroic and in the right. We urgently need to replace this indoctrination in chauvinism by a reformed view of history, where the slow development of human culture is described, giving credit to all who have contributed. When we teach history, it should not be about power struggles. It should be about how human culture was gradually built up over thousands of years by the patient work of millions of hands and minds. Our common global culture, the music, science, literature and art that all of us share, should be presented as a precious heritage - far too precious to be risked in a thermonuclear war.

We have to extend our loyalty to the whole of the human race, and to work for a world not only free from nuclear weapons, but free from war. A war-free world is not utopian but very practical, and not only practical but necessary. It is something that we can achieve and must achieve. Today their are large regions, such as the European Union, where war would be inconceivable. What is needed is to extend these.

Nor is a truly sustainable economic system utopian or impossible. To achieve it, we should begin by shifting jobs to the creation of renewable energy infrastructure, and to the fields of culture and education. By so doing we will support human solidarity and avoid the twin disasters of catastrophic war and climate change.

[8] http://www.fredsakademiet.dk/library/need.pdf
http://eruditio.worldacademy.org/issue-5/article/urgent-need-renewable-energy

[9] http://eruditio.worldacademy.org/article/evolution-cooperation



8.11 Construction versus destruction

It is often said that ethical principles cannot be derived from science , that they must come from somewhere else. Nevertheless, when nature is viewed through the eyes of modern science, we obtain some insights which seem almost ethical in character. Biology at the molecular level has shown us the complexity and beauty of even the most humble living organisms, and the interrelatedness of all life on earth. Looking through the eyes of contemporary biochemistry, we can see that even the single cell of an amoeba is a structure of miraculous complexity and precision, worthy of our respect and wonder.

Knowledge of the second law of thermodynamics , the statistical law favoring disorder over order, reminds us that life is always balanced like a tight-rope walker over an abyss of chaos and destruction. Living organisms distill their order and complexity from the flood of thermodynamic information which reaches the earth from the sun. In this way, they create local order; but life remains a fugitive from the second law of thermodynamics. Disorder, chaos, and destruction remain statistically favored over order, construction, and complexity.

It is easier to burn down a house than to build one, easier to kill a human than to raise and educate one, easier to force a species into extinction than to replace it once it is gone, easier to burn the Great Library of Alexandria than to accumulate the knowledge that once filled it, and easier to destroy a civilization in a thermonuclear war than to rebuild it from the radioactive ashes. Knowing this, we can form an almost ethical insight: To be on the side of order, construction, and complexity, is to be on the side of life. To be on the side of destruction, disorder, chaos and war is to be against life, a traitor to life, an ally of

Figure 8.9: **The second law of thermodynamics tells us that disorder is statistically favored over order, and that life is always balancing above a sea of chaos. It is easier to burn down a house than to build one, easier to burn down the Great Library at Alexandria than to accumulate the knowledge that once filled it, and easier to start a thermonuclear war than to rebuild civilization from the radioactive ashes.**

death. Knowing the precariousness of life, knowing the statistical laws that favor disorder and chaos, we should resolve to be loyal to the principle of long continued construction upon which life depends.

War is based on destruction, destruction of living persons, destruction of homes, destruction of infrastructure, and destruction of the biosphere. If we are on the side of life, if we are not traitors to life and allies of death, we must oppose the institution of war. We must oppose the military-industrial complex. We must oppose the mass media when they whip up war-fever. We must oppose politicians who vote for obscenely enormous military budgets at a time of financial crisis. We must oppose the planned illegal and insane Israeli attack of Iran, which threatens to lead to a world-destroying conflict. We must oppose these things by working with dedication, as though our lives depended on it. In fact, they do.

8.12 New ethics to match new technology

Modern science has, for the first time in history, offered humankind the possibility of a life of comfort, free from hunger and cold, and free from the constant threat of death through infectious disease. At the same time, science has given humans the power to obliterate their civilization with nuclear weapons, or to make the earth uninhabitable through overpopulation and pollution.

Figure 8.10: **We must develop a new system of ethics to match our advanced technology.**

The question of which of these paths we choose is literally a matter of life or death for ourselves and our children. Will we use the discoveries of modern science constructively, and thus choose the path leading towards life? Or will we use science to produce more and more lethal weapons, which sooner or later, through a technical or human failure, may result in a catastrophic nuclear war? Will we thoughtlessly destroy our beautiful planet through unlimited growth of population and industry? The choice among these alternatives is ours to make. We live at a critical moment of history, a moment of crisis for civilization.

No one living today asked to be born at such a moment, but by an accident of birth, history has given us an enormous responsibility, and two daunting tasks: If civilization is to survive, we must not only stabilize the global population but also, even more importantly, we must eliminate the institution of war. We face these difficult tasks with an inherited emotional nature that has not changed much during the last 40,000 years. Furthermore, we face the challenges of the 21st century with an international political system based on the anachronistic concept of the absolutely sovereign nation-state. However, the human brain has shown itself to be capable of solving even the most profound and complex problems. The mind that has seen into the heart of the atom must not fail when confronted with paradoxes of the human heart.

We must replace the old world of international anarchy, chronic war and institutionalized injustice, by a new world of law. The United Nations Charter, the Universal Declaration of Human Rights and the International Criminal Court are steps in the right direction, but these institutions need to be greatly strengthened and reformed.[10]

[10]http://www.countercurrents.org/zuesse050815.htm

We also need a new global ethic, where loyalty to one's family and nation is supplemented by a higher loyalty to humanity as a whole. The Nobel laureate biochemist Albert Szent-Györgyi once wrote:

"The story of man consists of two parts, divided by the appearance of modern science.... In the first period, man lived in the world in which his species was born and to which his senses were adapted. In the second, man stepped into a new, cosmic world to which he was a complete stranger.... The forces at man's disposal were no longer terrestrial forces, of human dimension, but were cosmic forces, the forces which shaped the universe. The few hundred Fahrenheit degrees of our flimsy terrestrial fires were exchanged for the ten million degrees of the atomic reactions which heat the sun."

"This is but a beginning, with endless possibilities in both directions; a building of a human life of undreamt of wealth and dignity, or a sudden end in utmost misery. Man lives in a new cosmic world for which he was not made. His survival depends on how well and how fast he can adapt himself to it, rebuilding all his ideas, all his social and political institutions."

"...Modern science has abolished time and distance as factors separating nations. On our shrunken globe today, there is room for one group only: the Family of man."

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Appendix A

MALTHUS AND HIS CONTEMPORARIES

A.1 The education of Malthus

T.R. Malthus' *Essay on The Principle of Population*, the first edition of which was published in 1798, was one of the the first systematic studies of the problem of population in relation to resources. Earlier discussions of the problem had been published by Boterro in Italy, Robert Wallace in England, and Benjamin Franklin in America. However Malthus' *Essay* was the first to stress the fact that, in general, powerful checks operate continuously to keep human populations from increasing beyond their available food supply. In a later edition, published in 1803, he buttressed this assertion with carefully collected demographic and sociological data from many societies at various periods of their histories.

The publication of Malthus' *Essay* coincided with a wave of disillusionment which followed the optimism of the Enlightenment. The utopian societies predicted by the philosophers of the Enlightenment were compared with reign of terror in Robespierre's France and with the miseries of industrial workers in England; and the discrepancy required an explanation. The optimism which preceded the French Revolution, and the disappointment which followed a few years later, closely paralleled the optimistic expectations of our own century, in the period after the Second World War, when it was thought that the transfer of technology to the less developed parts of the world would eliminate poverty, and the subsequent disappointment when poverty persisted. Science and technology developed rapidly in the second half of the twentieth century, but the benefits which they conferred were just as rapidly consumed by a global population which today is increasing at the rate of one billion people every decade. Because of the close parallel between the optimism and disappointments of Malthus' time and those of our own, much light can be thrown on our present situation by rereading the debate between Malthus and his contemporaries.

Thomas Robert Malthus (1766-1834) came from an intellectual family: His father, Daniel Malthus, was a moderately well-to-do English country gentleman, an enthusiastic believer in the optimistic ideas of the Enlightenment, and a friend of the philosophers Jean-

Figure A.1: **The Rookery near Dorking in Surrey**

Jaques Rousseau, David Hume and William Godwin. The famous book on population by the younger Malthus grew out of conversations with his father.

Daniel Malthus attended Oxford, but left without obtaining a degree. He later built a country home near Dorking, which he called "The Rookery". The house had Gothic battlements, and the land belonging to it contained a beech forest, an ice house, a corn mill, a large lake, and serpentine walks leading to "several romantic buildings with appropriate dedications". Daniel Malthus was an ardent admirer of Rousseau; and when the French philosopher visited England with his mistress, Thérése le Vasseur, Danial Malthus entertained him at the Rookery. Rousseau and Thérése undoubtedly saw Daniel's baby son (who was always called Robert or Bob) and they must have noticed with pity that he had been born with a hare lip. This was later sutured, and apart from a slight scar which marked the operation, he became very handsome.

Robert Malthus was at first tutored at home; but in 1782, when he was 16 years old, he was sent to study at the famous Dissenting Academy at Warrington in Lancashire. Joseph Priestly had taught at Warrington, and he had completed his famous *History of Electricity* there, as well as his *Essay on Government*, which contains the phrase "the greatest good for the greatest number".

Robert's tutor at Warrington Academy was Gilbert Wakefield (who was later imprisoned for his radical ideas). When Robert was 18, Wakefield arranged for him to be admitted to Jesus College, Cambridge University, as a student of mathematics. Robert Malthus graduated from Cambridge in 1788 with a first-class degree in mathematics. He was Ninth Wrangler, which meant that he was the ninth-best mathematician in his graduating class. He also won prizes in declamation, both in English and in Latin, which is surprising in view of the speech defect from which he suffered all his life.

A.2 Debate on the views of Godwin and Condorcet

In 1793, Robert Malthus was elected a fellow of Jesus College, and he also took orders in the Anglican Church. He was assigned as Curate to Okewood Chapel in Surrey. This small chapel stood in a woodland region, and Malthus' illiterate parishioners were so poor that the women and children went without shoes. They lived in low thatched huts made of woven branches plastered with mud. The floors of these huts were of dirt, and the only light came from tiny window openings. Malthus' parishioners diet consisted almost entirely of bread. The children of these cottagers developed late, and were stunted in growth. Nevertheless, in spite of the harsh conditions of his parishioners' lives, Malthus noticed that the number of births which he recorded in the parish register greatly exceeded the number of deaths. It was probably this fact which first turned his attention to the problem of population.

By this time, Daniel Malthus had sold the Rookery; and after a period of travel, he had settled with his family at Albury, about nine miles from Okewood Chapel. Robert Malthus lived with his parents at Albury, and it was here that the famous debates between father and son took place. 1793, the year when Robert Malthus took up his position at Okewood, was also the year in which Danial Malthus friend, William Godwin, published his enormously optimistic book, *Political Justice*. In this book, Godwin predicted a future society where scientific progress would liberate humans from material want. Godwin predicted that in the future, with the institution of war abolished, with a more equal distribution of property, and with the help of scientific improvements in agriculture and industry, much less labour would be needed to support life. Luxuries are at present used to maintain artificial distinctions between the classes of society, Godwin wrote, but in the future values will change; humans will live more simply, and their efforts will be devoted to self-fulfillment and to intellectual and moral improvement, rather than to material possessions. With the help of automated agriculture, the citizens of a future society will need only a few hours a day to earn their bread.

Godwin went on to say, "The spirit of oppression, the spirit of servility and the spirit of fraud - these are the immediate growth of the established administration of property. They are alike hostile to intellectual improvement. The other vices of envy , malice, and revenge are their inseparable companions. In a state of society where men lived in the midst of plenty, and where all shared alike the bounties of nature, these sentiments would inevitably expire. The narrow principle of selfishness would vanish. No man being obliged to guard his little store, or provide with anxiety and pain for his restless wants, each would lose his own individual existence in the thought of the general good. No man would be the enemy of his neighbor, for they would have nothing to contend; and of consequence philanthropy would resume the empire which reason assigns her. Mind would be delivered from her perpetual anxiety about corporal support, and free to expatiate in the field of thought which is congenial to her. Each man would assist the inquiries of all."

Godwin insisted that there is an indissoluble link between politics, ethics and knowledge. *Political Justice* is an enthusiastic vision of what humans could be like at some future period when the trend towards moral and intellectual improvement has lifted men

Figure A.2: **William Godwin (1756-1836).**

and women above their their present state of ignorance and vice. Much of the savage structure of the penal system would then be unnecessary, Godwin believed. (At the time when he was writing, there were more than a hundred capital offenses in England, and this number had soon increased to almost two hundred. The theft of any object of greater value than ten shillings was punishable by hanging.) In its present state, Godwin wrote, society decrees that the majority of its citizens "should be kept in abject penury, rendered stupid with ignorance and disgustful with vice, perpetuated in nakedness and hunger, goaded to the commission of crimes, and made victims to the merciless laws which the rich have instituted to oppress them". But human behavior is produced by environment and education, Godwin pointed out. If the conditions of upbringing were improved, behavior would also improve. In fact, Godwin believed that men and women are subject to natural laws no less than the planets of Newton's solar system. "In the life of every human", Godwin wrote, "there is a chain of causes, generated in that eternity which preceded his birth, and going on in regular procession through the whole period of his existence, in consequence of which it was impossible for him to act in any instance otherwise than he has acted."

The chain of causality in human affairs implies that vice and crime should be regarded with the same attitude with which we regard disease. The causes of poverty, ignorance, vice and crime should be removed. Human failings should be cured rather than punished. With this in mind, Godwin wrote, "our disapprobation of vice will be of the same nature as our disapprobation of an infectious distemper."

In France the Marquis de Condorcet had written an equally optimistic book, *Esquisse d'un Tableau Historique des Progrès de l'Esprit Humain*. Condorcet's optimism was unaffected even by the fact that at the time when he was writing he was in hiding, under sentence of death by Robespierre's government. Besides enthusiastically extolling Godwin's ideas to his son, Daniel Malthus also told him of the views of Condorcet.

Condorcet's *Esquisse*, is an enthusiastic endorsement of the idea of infinite human perfectibility which was current among the philosophers of the 18th century, and in this book, Condorcet anticipated many of the evolutionary ideas of Charles Darwin. He compared humans with animals, and found many common traits. Condorcet believed that animals are able to think, and even to think rationally, although their thoughts are extremely simple compared with those of humans. He also asserted that humans historically began their existence on the same level as animals and gradually developed to their present state. Since this evolution took place historically, he reasoned, it is probable, or even inevitable, that a similar evolution in the future will bring mankind to a level of physical, mental and moral development which will be as superior to our own present state as we are now superior to animals. In his *Esquisse*, Condorcet called attention to the unusually long period of dependency which characterizes the growth and education of human offspring. This prolonged childhood is unique among living beings. It is needed for the high level of mental development of the human species; but it requires a stable family structure to protect the young during their long upbringing.

Thus, according to Condorcet, biological evolution brought into existence a moral precept, the sanctity of the family.

Similarly, Condorcet maintained, larger associations of humans would have been impos-

Figure A.3: **Thomas Robert Malthus (1766-1834).**

Figure A.4: **The Marquis de Condorcet (1743-1794).**

sible without some degree of altruism and sensitivity to the suffering of others incorporated into human behavior, either as instincts or as moral precepts or both; and thus the evolution of organized society entailed the development of sensibility and morality.

Condorcet believed that ignorance and error are responsible for vice; and he listened what he regarded as the main mistakes of civilization: hereditary transmission of power, inequality between men and women, religious bigotry, disease, war, slavery, economic inequality, and the division of humanity into mutually exclusive linguistic groups.

Condorcet believed the hereditary transmission of power to be the source of much of the tyranny under which humans suffer; and he looked forward to an era when republican governments would be established throughout the world. Turning to the inequality between men and women, Condorcet wrote that he could see no moral, physical or intellectual basis for it. He called for complete social, legal, and educational equality between the sexes.

Condorcet predicted that the progress of medical science would free humans from the worst ravages of disease. Furthermore, he maintained that since perfectibility (i.e. evolution) operates throughout the biological world, there is no reason why mankind's physical

structure might not gradually improve, with the result that human life in the remote future could be greatly prolonged. Condorcet believed that the intellectual and moral facilities of man are capable of continuous and steady improvement; and he thought that one of the most important results of this improvement will be the abolition of war.

As Daniel Malthus talked warmly about Godwin, Condorcet, and the idea of human progress, the mind of his son, Robert, turned to the unbalance between births and deaths which he had noticed among his parishioners at Okewood Chapel. He pointed out to his father that no matter what benefits science might be able to confer, they would soon be eaten up by population growth. Regardless of technical progress, the condition of the lowest social class would remain exactly the same: The poor would continue to live, as they always had, on the exact borderline between survival and famine, clinging desperately to the lower edge of existence. For them, change for the worse was impossible since it would loosen their precarious hold on life; their children would die and their numbers would diminish until they balanced the supply of food. But any change for the better was equally impossible, because if more nourishment should become available, more of the children of the poor would survive, and the share of food for each of them would again be reduced to the precise minimum required for life.

Observation of his parishioners at Okewood had convinced Robert Malthus that this sombre picture was a realistic description of the condition of the poor in England at the end of the 18th century. Techniques of agriculture and industry were indeed improving rapidly; but among the very poor, population was increasing equally fast, and the misery of society's lowest class remained unaltered.

Daniel Malthus was so impressed with his son's arguments that he urged him to develop them into a small book. Robert Malthus' first essay on population, written in response to his father's urging, was only 50,000 words in length. It was was published anonymously in 1798, and its full title was *An Essay on the Principle of Population, as it affects the future improvement of society, with remarks on the speculations of Mr. Godwin, M. Condorcet, and other writers.* Robert Malthus' Essay explored the consequences of his basic thesis: that "the power of population is indefinitely greater than the power in the earth to produce subsistence for man".

A.3 Publication of the first essay in 1798

"That population cannot increase without the means of subsistence", Robert Malthus wrote, "is a proposition so evident that it needs no illustration. That population does invariably increase, where there are means of subsistence, the history of every people who have ever existed will abundantly prove. And that the superior power cannot be checked without producing misery and vice, the ample portion of these two bitter ingredients in the cup of human life, and the continuance of the physical causes that seem to have produced them, bear too convincing a testimony."

In order to illustrate the power of human populations to grow quickly to enormous numbers if left completely unchecked, Malthus turned to statistics from the United States,

where the population had doubled every 25 years for a century and a half. Malthus called this type of growth "geometrical" (today we would call it "exponential"); and, drawing on his mathematical education, he illustrated it by the progression 1,2,4,8,16,32,64,128,256,..etc. In order to show that, in the long run, no improvement in agriculture could possibly keep pace with unchecked population growth, Malthus allowed that, in England, agricultural output might with great effort be doubled during the next quarter century; but during a subsequent 25-year period it could not again be doubled. The growth of agricultural output could at the very most follow an arithmetic (linear) progression, 1,2,3,4,5,6,...etc.

Because of the overpoweringly greater numbers which can potentially be generated by exponential population growth, as contrasted to the slow linear progression of sustenance, Malthus was convinced that at almost all stages of human history, population has not expanded freely, but has instead pressed painfully against the limits of its food supply. He maintained that human numbers are normally held in check either by "vice or misery". (Malthus classified both war and birth control as a forms of vice.) Occasionally the food supply increases through some improvement in agriculture, or through the opening of new lands; but population then grows very rapidly, and soon a new equilibrium is established, with misery and vice once more holding the population in check.

Like Godwin's *Political Justice*, Malthus' *Essay on the Principle of Population* was published at exactly the right moment to capture the prevailing mood of England. In 1793, the mood had been optimistic; but by 1798, hopes for reform had been replaced by reaction and pessimism. Public opinion had been changed by Robespierre's Reign of Terror and by the threat of a French invasion. Malthus' clear and powerfully written essay caught the attention of readers not only because it appeared at the right moment, but also because his two contrasting mathematical laws of growth were so striking.

One of Malthus' readers was William Godwin, who recognized the essay as the strongest challenge to his utopian ideas that had yet been published. Godwin several times invited Malthus to breakfast at his home to discuss social and economic problems. (After some years, however, the friendship between Godwin and Malthus cooled, the debate between them having become more acrimonious.)

In 1801, Godwin published a reply to his critics, among them his former friends James Mackintosh and Samuel Parr, by whom he recently had been attacked. His *Reply to Parr* also contained a reply to Malthus: Godwin granted that the problem of overpopulation raised by Malthus was an extremely serious one. However, Godwin wrote, all that is needed to solve the problem is a change of the attitudes of society. For example we need to abandon the belief "that it is the first duty of princes to watch for (i.e. encourage) the multiplication of their subjects, and that a man or woman who passes the term of life in a condition of celibacy is to be considered as having failed to discharge the principal obligations owed to the community". "On the contrary", Godwin continued, "it now appears to be rather the man who rears a numerous family that has to some degree transgressed the consideration he owes to the public welfare". Godwin suggested that each marriage should be allowed only two or three children or whatever number might be needed to balance the current rates of mortality and celibacy. This duty to society, Godwin wrote, would surely not be too great a hardship to be endured, once the reasons for it were thoroughly understood.

A.4 The second essay published in 1803

Malthus' small essay had captured public attention in England, and he was anxious to expand it with empirical data which would show his principle of population to be valid not only in England in his own day, but in all societies and all periods. He therefore traveled widely, collecting data. He also made use of the books of explorers, such as Cook and Vancouver.

Malthus second edition - more than three times the length of his original essay on population - was ready in 1803. Book I and Book II of the 1803 edition of Malthus' *Essay* are devoted to a study of the checks to population growth which have operated throughout history in all the countries of the world for which he possessed facts.

In his first chapter, Malthus stressed the potentially enormous power of population growth contrasted the slow growth of the food supply. He concluded that strong checks to the increase of population must almost always be operating to keep human numbers within the bounds of sustenance. He classified the checks as either preventive or positive, the preventive checks being those which reduce fertility, while the positive checks are those which increase mortality. Among the positive checks, Malthus listed "unwholesome occupations, severe labour and exposure to the seasons, extreme poverty, bad nursing of children, great towns, excesses of all kinds, the whole train of common diseases and epidemics, wars, plague, and famine".

In the following chapters of Books I, Malthus showed in detail the mechanisms by which population is held at the level of sustenance in various cultures. He first discussed primitive hunter-gatherer societies, such as the inhabitants of Tierra del Fuego, Van Diemens Land and New Holland, and those tribes of North American Indians living predominantly by hunting. In hunting societies, he pointed out, the population is inevitably very sparse: "The great extent of territory required for the support of the hunter has been repeatedly stated and acknowledged", Malthus wrote, "...The tribes of hunters, like beasts of prey, whom they resemble in their mode of subsistence, will consequently be thinly scattered over the surface of the earth."

"Like beasts of prey, they must either drive away or fly from every rival, and be engaged in perpetual contests with each other...The neighboring nations live in a perpetual state of hostility with each other. The very act of increasing in one tribe must be an act of aggression against its neighbors, as a larger range of territory will be necessary to support its increased numbers.

'The contest will in this case continue, either till the equilibrium is restored by mutual losses, or till the weaker party is exterminated or driven from its country... Their object in battle is not conquest but destruction. The life of the victor depends on the death of the enemy". Malthus concluded that among the American Indians of his time, war was the predominant check to population growth, although famine, disease and infanticide each played a part.

In the next chapter, Malthus quoted Captain Cook's description of the natives of the region near Queen Charlotte's Sound in New Zealand, whose way of life involved perpetual war. "If I had followed the advice of all our pretended friends", Cook wrote, "I might have

extirpated the whole race; for the people of each hamlet or village, by turns, applied to me to destroy the other". According to Cook, the New Zealanders practiced both ceaseless war and cannibalism; and population pressure provided a motive for both practices.

In later chapters on nomadic societies of the Near East and Asia, war again appears, not only as a consequence of the growth of human numbers, but also as one of the major mechanisms by which these numbers are reduced to the level of their food supply. The studies quoted by Malthus make it seem likely that the nomadic Tartar tribes of central Asia made no use of the preventive checks to population growth. In fact the Tartar tribes may have regarded growth of their own populations as useful in their wars with neighboring tribes.

Malthus also described the Germanic tribes of Northern Europe, whose population growth led them to the attacks which destroyed the Roman Empire.

He quoted the following passage from Machiavelli's History of Florence: "The people who inhabit the northern parts that lie between the Rhine and the Danube, living in a healthful and prolific climate, often increase to such a degree that vast numbers of them are forced to leave their native country and go in search of new habitations. When any of those provinces begins to grow too populous and wants to disburden itself, the following method is observed. In the first place, it is divided into three parts, in each of which there is an equal portion of the nobility and commonality, the rich and the poor. After this they cast lots; and that division on which the lot falls quits the country and goes to seek its fortune, leaving the other two more room and liberty to enjoy their possessions at home. These emigrations proved the destruction of the Roman Empire". Regarding the Scandinavians in the early middle ages, Malthus wrote: "Mallet relates, what is probably true, that it was their common custom to hold an assembly every spring for the purpose of considering in what quarter they should make war".

In many of the societies which Malthus described, a causal link can be seen, not only between population pressure and poverty, but also between population pressure and war. As one reads his *Essay*, it becomes clear why both these terrible sources of human anguish saturate so much of history, and why efforts to eradicate them have so often met with failure: The only possible way to eliminate poverty and war is to reduce the pressure of population by preventive checks, since the increased food supply produced by occasional cultural advances can give only very temporary relief.

In Book II, Malthus turned to the nations of Europe, as they appeared at the end of the 18th century, and here he presents us with a different picture. Although in these societies poverty, unsanitary housing, child labour, malnutrition and disease all took a heavy toll, war produced far less mortality than in hunting and pastoral societies, and the preventive checks, which lower fertility, played a much larger roll.

Malthus had visited Scandinavia during the summer of 1799, and he had made particularly detailed notes on Norway. He was thus able to present a description of Norwegian economics and demography based on his own studies. Norway was remarkable for having the lowest reliably-recorded death rate of any nation at that time: Only 1 person in 48 died each year in Norway. (By comparison, 1 person in 20 died each year in London.) The rate of marriage was also remarkably low, with only 1 marriage each year for every 130

Figure A.5: **Captain James Cook, FRS (1728-1779). According to Cook, the native New Zealanders practiced both ceaseless war and cannibalism; and population pressure provided a motive for both practices. Malthus based his description of hunter-gatherer societies on the writings of explorers such as Cook and Vancouver.**

inhabitants; and thus in spite of the low death rate, Norway's population had increased only slightly from the 723,141 inhabitants recorded in 1769.

There were two reasons for late marriage in Norway: Firstly, every man born of a farmer or a labourer was compelled by law to be a soldier in the reserve army for a period of ten years; and during his military service, he could not marry without the permission of both his commanding officer and the parish priest. These permissions were granted only to those who were clearly in an economic position to support a family. Men could be inducted into the army at any age between 20 and 30, and since commanding officers preferred older recruits, Norwegian men were often in their 40's before they were free to marry. At the time when Malthus was writing, these rules had just been made less restrictive; but priests still refused to unite couples whose economic foundations they judged to be insufficient.

The second reason for late marriages was the structure of the farming community. In general, Norwegian farms were large; and the owner's household employed many young unmarried men and women as servants. These young people had no chance to marry unless a smaller house on the property became vacant, with its attached small parcel of land for the use of the "houseman"; but because of the low death rate, such vacancies were infrequent.

Thus Norway's remarkably low death rate was balanced by a low birth rate. Other chapters in Book II are devoted to the checks to population growth in Sweden, Russia, Central Europe, Switzerland, France, England, Scotland and Ireland.

Malthus painted a very dark panorama of population pressure and its consequences in human societies throughout the world and throughout history: At the lowest stage of cultural development are the hunter-gatherer societies, where the density of population is extremely low. Nevertheless, the area required to support the hunters is so enormous that even their sparse and thinly scattered numbers press hard against the limits of sustenance. The resulting competition for territory produces merciless intertribal wars.

The domestication of animals makes higher population densities possible; and wherever this new mode of food production is adopted, human numbers rapidly increase; but very soon a new equilibrium is established, with the population of pastoral societies once more pressing painfully against the limits of the food supply, growing a little in good years, and being cut back in bad years by famine, disease and war.

Finally, agricultural societies can maintain extremely high densities of population; but the time required to achieve a new equilibrium is very short. After a brief period of unrestricted growth, human numbers are once more crushed against the barrier of limited resources; and if excess lives are produced by overbreeding, they are soon extinguished by deaths among the children of the poor.

Malthus was conscious that he had drawn an extremely dark picture of the human condition. He excused himself by saying that he has not done it gratuitously, but because he was convinced that the dark shades really are there, and that they form an important part of the picture. He did allow one ray of light, however: By 1803, his own studies of Norway, together with personal conversations with Godwin and the arguments in Godwin's *Reply to Parr*, had convinced Malthus that "moral restraint" should be included among the possible checks to population growth. Thus he concluded Book II of his 1803 edition by

saying that the checks which keep population down to the level of the means of subsistence can all be classified under the headings of "moral restraint, vice and misery". (In his first edition he had maintained that vice and misery are the only possibilities).

A.5 Systems of equality

In the 1803 edition of Malthus' *Essay*, Books III and IV form a second volume.

The ideas which he put forward in this second volume are much more open to dispute than are the solidly empirical demographic studies of Books I and II. Malthus excused himself at the beginning of the second volume, saying that he realized that the ideas which he was about to put forward were less solidly based than those in his first volume. However, he said that he wished to explore all the consequences of his principle of population: "..Even the errors into which I may have fallen", he wrote, "by according a handle to argument, and an additional excitement to examination, may be subservient to the important end of bringing a subject so nearly connected with the happiness of society into more general notice".

Malthus began Book III by discussing the systems of equality proposed by Condorcet and Godwin; and he tried to show that such utopian societies would prove impossible in practice, because they would rapidly drown in a flood of excess population. Condorcet himself had recognized this difficulty. He realized that improved living conditions for the poor would lead to a rapid growth of population. "Must not a period then arrive", Condorcet had written, "... when the increase of the number of men surpassing their means of subsistence, the necessary result must be either a continual diminution of happiness and population... or at least a kind of oscillation between good and evil?"

Condorcet believed the serious consequences of population pressure to be far in the future, but Malthus disagreed with him on exactly that point: "M. Condorcet's picture of what may be expected to happen when the number of men shall surpass subsistence is justly drawn... The only point in which I differ from M. Condorcet in this description is with regard to the period when it may be applied to the human race... This constantly subsisting cause of periodical misery has existed in most countries ever since we have had any histories of mankind, and continues to exist at the present moment."

"M. Condorcet, however, goes on to say", Malthus continued, "that should the period, which he conceives to be so distant, ever arrive, the human race, and the advocates of the perfectibility of man, need not be alarmed at it. He then proceeds to remove the difficulty in a manner which I profess not to understand. Having observed that the ridiculous prejudices of superstition would by that time have ceased to throw over morals a corrupt and degrading austerity, he alludes either to a promiscuous concubinage, which would prevent breeding, or to something else as unnatural. To remove the difficulty in this way will surely, in the opinion of most men, be to destroy that virtue and purity of manners which the advocates of equality and of the perfectibility of man profess to be the end and object of their views."

When Malthus referred to "something else as unnatural", he of course meant birth

control, some forms of which existed at the time when he was writing; and in this passage we see that he was opposed to the practice. He preferred late marriage or "moral restraint" as a means of limiting excessive population growth.

After his arguments against Condorcet, Malthus discussed William Godwin's egalitarian utopia, which, he said, would be extremely attractive if only it could be achieved: "The system of equality which Mr. Godwin proposes", Malthus wrote, "is, on the first view of it, the most beautiful and engaging which has yet appeared. A melioration of society to be produced merely by reason and conviction gives more promise of permanence than than any change effected and maintained by force. The unlimited exercise of private judgement is a doctrine grand and captivating, and has a vast superiority over those systems where every individual is in a manner the slave of the public."

"The substitution of benevolence, as a master-spring and moving principle of society, instead of self-love, appears at first sight to be a consummation devoutly to be wished. In short, it is impossible to contemplate the whole of this fair picture without emotions of delight and admiration, accompanied with an ardent longing for the period of its accomplishment."

"But alas!" Malthus continued, "That moment can never arrive.... The great error under which Mr. Godwin labours throughout his whole work is the attributing of almost all the vices and misery that prevail in civil society to human institutions. Political regulations and the established administration of property are, with him, the fruitful sources of all evil, the hotbeds of all the crimes that degrade mankind. Were this really a true state of the case, it would not seem a completely hopeless task to remove evil completely from the world; and reason seems to be the proper and adequate instrument for effecting so great a purpose. But the truth is, that though human institutions appear to be, and indeed often are, the obvious and obtrusive causes of much misery in society, they are, in reality, light and superficial in comparison with those deeper-seated causes of evil which result from the laws of nature and the passions of mankind."

The passions of mankind drive humans to reproduce, while the laws of nature set limits to the carrying capacity of the environment. Godwin's utopia, if established, would be very favorable to the growth of population; and very soon the shortage of food would lead to its downfall: Because of the overpowering force of population growth, "Man cannot live in the midst of plenty. All cannot share alike the bounties of nature. Were there no established administration of property, every man would be obliged to guard with his force his little store. Selfishness would be triumphant. The subjects of contention would be perpetual. Every individual would be under constant anxiety about corporal support, and not a single intellect would be left free to expatiate in the field of thought."

Malthus believed that all systems of equality are doomed to failure, not only because of the powerful pressure of population growth, but also because differences between the upper, middle, and lower classes serve the useful purpose of providing humans with an incentive for hard work. He thought that fear of falling to a lower social status, and hope of rising to a higher one, provide a strong incentive for constructive activity. However, he believed that happiness is most often found in the middle ranks of society, and that therefore the highest and lowest classes ought not to be large. Malthus advocated universal

education and security of property as means by which the lowest classes of society could be induced to adopt more virtuous and prudent patterns of behavior.

A.6 The Poor Laws

Among the most controversial chapters of Malthus' second volume are those dealing with the Poor Laws. During the reign of Queen Elisabeth I, a law had been enacted according to which justices were authorized to collect taxes in order to set to work "...the children of all such, whose parents shall not by the said persons be thought able to keep and maintain their children; and also such persons, married or unmarried, as, having no means to maintain them, use no ordinary or daily trade to get their living by..". Malthus commented:

"What is this but saying that the funds for the maintenance of labour in this country may be increased without limit by a fiat of government...? Strictly speaking, this clause is as arrogant and absurd as if it had enacted that two ears of wheat should in the future grow where one had grown before. Canute, when he commanded the waves not to wet his princely foot, did not assume a greater power over the laws of nature." Malthus pointed out that if we believe that every person has a right to have as many children as he or she wishes, and if we enact a law, according to which every person born has a right to sustenance, then we implicitly assume that the supply of food can be increased without limit, which of course is impossible.

During the first few years of the nineteenth century there was a severe shortage of food in England, partly because of war with France, and partly because of harvest failures. As a result, the price of wheat tripled, causing great distress among the poor. By 1803, 3,000,000 pounds sterling were being distributed to make up the difference between the wages of poor workers and the amount which they needed to pay for food. Malthus regarded the supply of grain as constant, i.e. independent of the price; and he therefore believed that distribution of money under the Poor Laws merely raised the price of grain still further in relation to wages, forcing a larger number of independent workers to seek help. He thought that the distributed money helped to relieve suffering in some cases, but that it spread the suffering over a wider area.

In some parishes, the amount of money distributed under the Poor Laws was proportional to the number of children in a family, and Malthus believed that this encouraged the growth of population, further aggravating the shortage of food. "A poor man may marry with little or no prospect of being able to support a family in independence", he wrote, "...and the Poor Laws may be said therefore in some measure to create the poor which they maintain; and as the provisions of the country must, in consequence of the increased population, be distributed to every man in smaller proportions, it is evident that the labour of those who are not supported by parish assistance, will purchase a smaller quantity of provisions than before, and consequently more of them must be driven to ask for support." Malthus advocated a very gradual abolition of the Poor Laws, and he believed that while this change was being brought about, the laws ought to be administered in such a way that the position of least well-off independent workers should not be worse than the position of

those supported by parish assistance.

A.7 Replies to Malthus

The second edition of Malthus' *Essay* was published in 1803. It provoked a storm of controversy, and a flood of rebuttals. In 1803 England's political situation was sensitive. Revolutions had recently occurred both in America and in France; and in England there was much agitation for radical change, against which Malthus provided counter-arguments. Pitt and his government had taken Malthus' first edition seriously, and had abandoned their plans for extending the Poor Laws. Also, as a consequence of Malthus' ideas, England's first census was taken in 1801. This census, and subsequent ones, taken in 1811, 1821 and 1831, showed that England's population was indeed increasing rapidly, just as Malthus had feared. (The population of England and Wales more than doubled in 80 years, from an estimated 6.6 million in 1750 to almost 14 million in 1831.) In 1803, the issues of poverty and population were at the center of the political arena, and articles refuting Malthus began to stream from the pens of England's authors.

William Coleridge planned to write an article against Malthus, and he made extensive notes in the margins of his copy of the *Essay*. In one place he wrote: "Are Lust and Hunger both alike Passions of physical Necessity, and the one equally with the other independent of the Reason and the Will? Shame upon our race that there lives an individual who dares to ask the Question." In another place Coleridge wrote: "Vice and Virtue subsist in the agreement of the habits of a man with his Reason and Conscience, and these can have but one moral guide, Utility, or the virtue and Happiness of Rational Beings". Although Coleridge never wrote his planned article, his close friend Robert Southey did so, using Coleridge's notes almost verbatim. Some years later Coleridge remarked: "Is it not lamentable - is it not even marvelous - that the monstrous practical sophism of Malthus should now have gained complete possession of the leading men of the kingdom! Such an essential lie in morals - such a practical lie in fact it is too! I solemnly declare that I do not believe that all the heresies and sects and factions which ignorance and the weakness and wickedness of man have ever given birth to, were altogether so disgraceful to man as a Christian, a philosopher, a statesman or citizen, as this abominable tenet."

In 1812, Percy Bysshe Shelley, who was later to become William Godwin's son-in-law, wrote: "Many well-meaning persons... would tell me not to make people happy for fear of over-stocking the world... War, vice and misery are undoubtedly bad; they embrace all that we can conceive of temporal and eternal evil. Are we to be told that these are remedyless, because the earth would in case of their remedy, be overstocked?" A year later, Shelley called Malthus a "priest, eunuch, and tyrant", and accused him, in a pamphlet, of proposing that ".. after the poor have been stript naked by the taxgatherer and reduced to bread and tea and fourteen hours of hard labour by their masters.. the last tie by which Nature holds them to benignant earth (whose plenty is garnered up in the strongholds of their tyrants) is to be divided... They are required to abstain from marrying under penalty of starvation... whilst the rich are permitted to add as many mouths to consume

Figure A.6: **Coleridge's notes on Malthus: "I do not believe that all the heresies and sects and factions which ignorance and the weakness and wickedness of man have ever given birth to, were altogether so disgraceful to man as a Christian, a philosopher, a statesman or citizen, as this abominable tenet."**

the products of the poor as they please".

Godwin himself wrote a long book (which was published in 1820) entitled Of *Population, An Enquiry Concerning the Power and Increase in the Number of Mankind, being an answer to Mr. Malthus.* One can also view many of the books of Charles Dickens as protests against Malthus' point of view. For example, Oliver Twist gives us a picture of a workhouse "administered in such a way that the position of least well-off independent workers should not be worse than the position of those supported by parish assistance."

Among the authors defending Malthus was Harriet Martineau, who wrote: "The desire of his heart and the aim of his work were that domestic virtue and happiness should be placed within the reach of all... He found that a portion of the people were underfed, and that one consequence of this was a fearful mortality among infants; and another consequence the growth of a recklessness among the destitute which caused infanticide,

Figure A.7: **Shelley: "'.. after the poor have been stript naked by the taxgatherer and reduced to bread and tea and fourteen hours of hard labour by their masters.. the last tie by which Nature holds them to benignant earth (whose plenty is garnered up in the strongholds of their tyrants) is to be divided...They are required to abstain from marrying under penalty of starvation..."**

Figure A.8: **Tiny Tim, from Charles Dickens' *A Christmas Carol*. When he is informed that Tiny Tim will die unless he receives medical treatment, Scrooge remarks, "Then he had better die and reduce the surplus population!". Many of the events in Dickens' books can be viewed as protests against the ideas of Malthus.**

Figure A.9: **Charles Dickens' Oliver Twist asks for a second portion of gruel, provoking a storm of outrage. As a boy, Dickens himself spent some time in a workhouse.**

Figure A.10: **A portrait of the British political economist, author and social theorist Harriet Martineau (1802-1876). She was a very close friend of Charles Darwin's older brother, Erasmus. Commenting on the ideas of Malthus, she wrote: "Prudence as to time of marriage and making due provision for it was, one would think, a harmless recommendation enough, under the circumstances." Martineau's books were highly successful, sometimes outselling those of Charles Dickens.**

corruption of morals, and at best, marriage between pauper boys and girls; while multitudes of respectable men and women, who paid rates instead of consuming them, were unmarried at forty or never married at all. Prudence as to time of marriage and for making due provision for it was, one would think, a harmless recommendation enough, under the circumstances."

A.8 Ricardo's Iron Law of Wages; the Corn Laws

Malthus continued a life of quiet scholarship, unperturbed by the heated public debate which he had caused. At the age of 38, he married a second cousin. The marriage produced only three children, which at that time was considered to be a very small number. Thus he practiced the pattern of late marriage which he advocated. Although he was appointed rector of a church in Lincolnshire, he never preached there, hiring a curate to do this in his place. Instead of preaching, Malthus accepted an appointment as Professor of History and Political Economy at the East India Company's College at Haileybury. This appointment made him the first professor of economics in England, and probably also the first in the world. Among the important books which he wrote while he held this post was *Principles of Political Economy, Considered with a View to their Practical Application.* Malthus also published numerous revised and expanded editions of his *Essay on the Principle of Population.* The third edition was published in 1806, the fourth in 1807, the fifth in 1817, and the sixth in 1826.

Malthus became a close friend of the wealthy financier and economic theorist, David Ricardo (1772-1823). He and Ricardo met frequently to discuss economic problems, and when circumstances prevented them from meeting, they exchanged endless letters. Ricardo and Malthus differed on the subject of the Corn Laws, but they never allowed this difference of opinion to affect their friendship.

Although shortages of food had produced drastic increases in the price of grain, the import of cheap foreign grain was effectively prevented by the Corn Laws. These laws had been introduced by the large landowners, who controlled Parliament, but they were opposed by the manufacturers, who wished to make less expensive food available to their workers. On this issue, Malthus sided with the landowners, arguing that if England became dependent on imports of foreign grain, the country would be insecure: What if England's ability to export manufactured goods in exchange for the grain should later be undermined by foreign competition? Malthus pointed out that the country would then face starvation. Ricardo, on the other hand, sided with the rising class of manufacturers. In 1832 the Reform Bill gave the manufacturers control of Parliament, the Corn Laws were repealed, and England's rapidly-growing population became dependent on imports of foreign grain.

Ricardo accepted Malthus' principle of population, and from it he deduced what came to be called his "Iron Law of Wages". According to Ricardo, labor is a commodity, and wages are determined by the law of supply and demand: When wages fall below the starvation level, the workers' children die. Labor then becomes a scarce commodity, and wages rise. On the other hand, when wages rise above the starvation level, the working population

Figure A.11: **The economist David Ricardo (1772-1823), a close friend of Malthus. The joint pessimism of Ricardo and Malthus caused Carlyle to call economics "the dismal science".**

multiplies rapidly, labor becomes a plentiful commodity, and wages fall again.

Thus, according to Ricardo, there is an Iron Law which holds wages at the minimum level at which life can be supported. The combined pessimism of Malthus and Ricardo caused Carlyle to call economics "the dismal science".

A.9 The Irish Potato Famine of 1845

Meanwhile, in Ireland, a dramatic series of events had occurred, confirming the ideas of Malthus. Anti-Catholic laws prevented the Irish cottagers from improving their social position; and instead they produced large families, fed almost exclusively on a diet of milk and potatoes. The potato and milk diet allowed a higher density of population to be supported in Ireland than would have been the case if the Irish diet had consisted primarily of wheat. As a result, the population of Ireland grew rapidly: In 1695 it had been approximately one million, but by 1821 it had reached 6,801,827. By 1845, the population of Ireland was more than eight million; and in that year the potato harvest failed because of blight. All who were able to do so fled from the country, many emigrating to the United States; but two million people died of starvation. As the result of this shock, Irish marriage habits changed, and late marriage became the norm, just as Malthus would have wished. After the Potato Famine of 1845, Ireland maintained a stable population of roughly four million.

Figure A.12: **The Irish Potato Famine.**

Figure A.13: **The Irish Potato Famine.**

A.10 The impact of Malthus on biology

The impact of Malthus' *Essay* was great, not only in demography and political economics, but also in biology. In 1836, Charles Darwin returned from his voyage on the Beagle with a mass of facts and ideas on species out of which he was struggling to construct a coherent picture; and Malthus gave him the clue he needed. "In October, 1838", Darwin wrote later in his Autobiography, "that is, fifteen months after I had begun my systematic enquiry, I happened to read for amusement 'Malthus on Population', and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favorable variations would tend to be preserved, and unfavorable ones to be destroyed. The result of this would be the formation of new species. Here then I had at last got a theory by which to work..."

Darwin wrote a sketch of his theory of evolution through natural selection; but he did not publish it, probably because he had a premonition of the furious opposition which his heretical ideas would provoke. In 1854 he returned to his work on species, but he was writing on a scale which would have developed into an enormous multi-volume work, whose completion might have taken the remainder of his life. Meanwhile, a young English biologist named Alfred Russell Wallace, working in the jungles of Malaysia, arrived at exactly the same theory as Darwin's, and in exactly the same way - by reading Malthus! Wallace wrote a short paper describing his theory and sent it to Darwin, asking the older scientist's opinion. Darwin was at first inclined to burn all his own work on the subject out of fairness to Wallace, but his friends persuaded him to instead write a short paper describing his views, which could be presented together with Wallace's article. The two papers were read together to a meeting of the Linnean Society, which listened in stunned silence. Posterity has given both Darwin and Wallace credit for their joint discovery of the theory of evolution through natural selection.

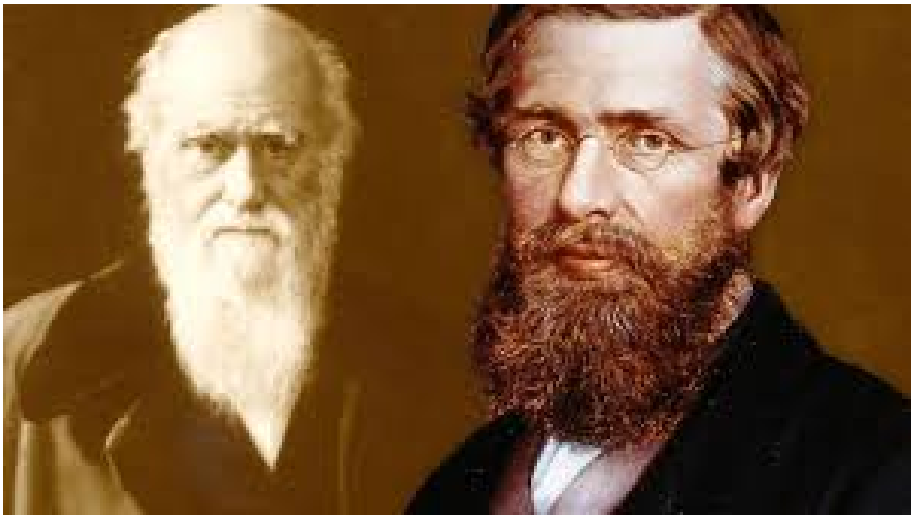

Figure A.14: **Both Charles Darwin and Alfred Russel Wallace arrived at their theories of natural selection in evolution as a result of reading Malthus.**

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Appendix B

THE BATTLE FOR BIRTH CONTROL

B.1 Birth Control in England: The Utilitarians

James Mill and John Stuart Mill

John Stuart Mill (1806-1873) showed his genius at an early age, and his father, the Utilitarian philosopher and political economist James Mill, immediately began to groom him to replace Jeremy Bentham as the leader of the Utilitarian movement. From the age of 3 onwards, Mill was deliberately kept away from children of his own age and made to spend all his waking hours in study. Play was not allowed, since it would break the habit of continual diligence.

At the age of three, Mill was taught Greek. By the time he reached eight, he had read Aesop's Fables, Xenophon's Anabasis, and all the works of Herodotus. He was also acquainted with Lucian, Diogenes Laërtius, Isocrates and six dialogues of Plato, in their original language. Furthermore, he had also read a great deal of history in English and had been taught arithmetic, physics and astronomy.

When he was twelve, Mill began a thorough study of the scholastic logic, at the same time reading Aristotle's logical treatises in the original language. At thirteen, he was introduced to political economy and studied the classical economists Adam Smith and David Ricardo. In fact Ricardo, who was a close friend of his father, used to invite the young Mill to his house for a walk in order to talk about political economy.

At the age of fourteen, Mill spent a year in France, where he attended the winter courses on chemistry, zoology, logic of the Faculté des Sciences, as well as taking a course of the higher mathematics. He also met the economist Jean-Baptiste Say, a friend of his father, and the political philosopher Henri Saint-Simon.

Figure B.1: **The Utilitarian philosopher and political economist James Mill (1773-1836) was an early advocate of birth control. In his Elements of Political Economy, he wrote: "The result to be aimed at is to secure to the great body of the people all the happiness which is capable of being derived from the matrimonial union, (while) preventing the evils which the too rapid increase of their numbers would entail. The progress of legislation, the improvement of the education of the people, and the decay of superstition will, in time, it may be hoped, accomplish the difficult task of reconciling these important objects."**

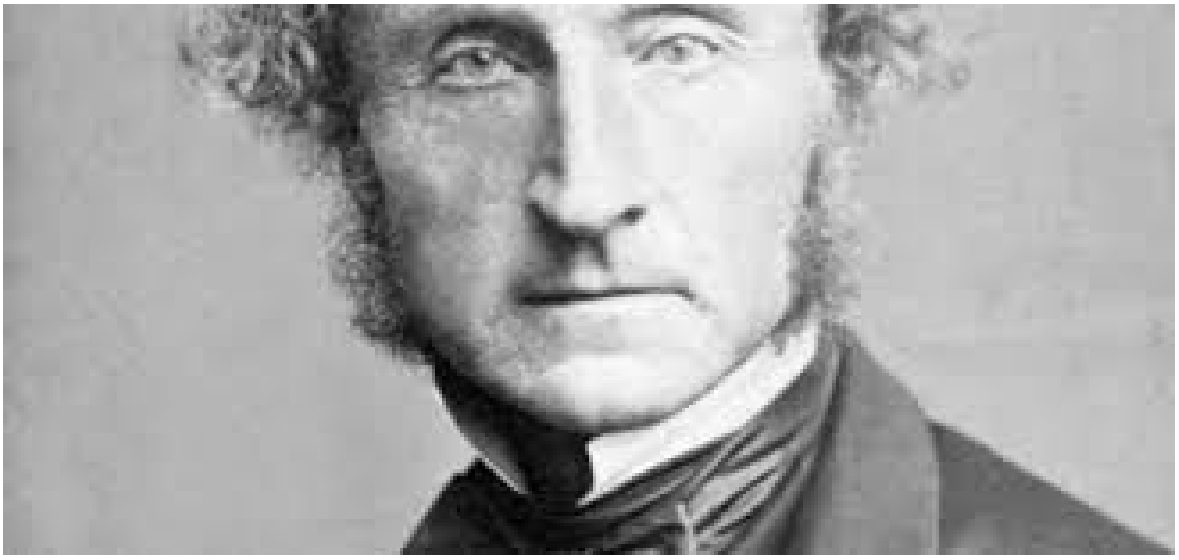

Figure B.2: **As a Member of Parliament, John Stuart Mill (1806-1873) introduced a law, the first of its kind, to give votes to women. Unfortunately it was defeated, but it set a precedent. He also foresaw that economic growth would have to end.**

Limits to growth

John Stuart Mill pioneered the concept of a steady.state economy. He realized that on a finite earth, neither the population of humans nor the economy can continue to grow forever. In 1848 (when there were just over one billion people in the world), he described the optimal global population in the following words:

"The density of population necessary to enable mankind to obtain, in the greatest degree, all the advantages of cooperation and social intercourse, has, in the most populous countries, been attained. A population may be too crowded, although all be amply supplied with food and raiment."

"... Nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings; every flowery waste or natural pasture plowed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture. If the earth must lose that great portion of its pleasantness which it owes to things that the unlimited increase of wealth and population would extirpate from it, for the mere purpose of enabling it to support a larger, but not better or happier population, I sincerely hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it."

Contributions to Utilitarian theory

Jeremy Bentham (1748-1832) had written that "it is the greatest happiness of the greatest number that is the measure of right and wrong". Mill refined this basic principle of Utilitarianism by pointing out the difference between higher pleasures, for example moral or intellectual pleasures, and lower ones, such as pleasures of the flesh. Mill remarked that "It is better to be a human being dissatisfied than a pig satisfied; better to be Socrates dissatisfied than a fool satisfied. And if the fool, or the pig, are of a different opinion, it is because they only know their own side of the question."

Ideas on economics and on individual liberty

According to David Ricardo's "Iron Law of Wages", laborers must always live on the exact borderline between starvation and survival. Wages, Ricardo argued, are determined by the laws of supply and demand. If wages increase above the starvation level, more children of workers survive, the supply of workers increases, and the wages fall once more.

Mill rebelled against Ricardo's dismal "Iron Law" by pointing out that although the means of production might be regulated by the necessities of economics, social conscience can determine the way in which the goods are distributed. (Later Mahatma Gandhi extended this idea by showing that social conscience can also play a role in the way that goods are produced).

John Stuart Mill also contributed importantly to the idea of individual liberty as opposed to unlimited control by the state or by social opinion. He is the author of the following influential principle: "The only purpose for which power can be rightfully exercised over any member of a civilized community, against his will, is to prevent harm to others."

Opposition to slavery

Regarding slavery, Mill wrote: "This absolutely extreme case of the law of force, condemned by those who can tolerate almost every other form of arbitrary power, and which, of all others, presents features the most revolting to the feeling of all who look at it from an impartial position, was the law of civilized and Christian England within the memory of persons now living: and in one half of Angle-Saxon America three or four years ago, not only did slavery exist, but the slave trade, and the breeding of slaves expressly for it, was a general practice between slave states. Yet not only was there a greater strength of sentiment against it, but, in England at least, a less amount either of feeling or of interest in favour of it, than of any other of the customary abuses of force: for its motive was the love of gain, unmixed and undisguised: and those who profited by it were a very small numerical fraction of the country, while the natural feeling of all who were not personally interested in it, was unmitigated abhorrence."

Member of Parliament and advocate of for votes for women

During the years between 1865 and 1868, John Stuart Mill served simultaneously as a Member of Parliament and as Lord Rector of the University of St. Andrews. In Parliament, Mill was the first person to call for votes for women. His motion was defeated, but it set an important precedent. Mill may have been influenced by his wife, Harriet Taylor Mill, who was a brilliant person in her own right.

Together with his wife and stepdaughter, Mill composed a book entitled *The Subjugation of Women*, which was completed in 1861. It contains a passage arguing that "the legal subordination of one sex to another - is wrong in itself, and now one of the chief hindrances to human improvement; and that it ought to be replaced by a system of perfect equality, admitting no power and privilege on the one side, nor disability on the other.

Ricardo's model accurately described the condition of industrial workers at the time when he was living. However, this model did not take into account the possibility of trade unions and social legislation fixing the minimum wage; nor did Ricardo's model take into account the possibility that workers would use birth control to limit their population growth.

We have seen that Malthus himself was opposed to birth control, advocating late marriage and "moral restraint" instead as the proper means for avoiding excessive population growth. However others in England, notably the Utilitarians, while accepting Malthus' ideas concerning population pressure, advocated birth control as a means of relieving it. In 1821, the Utilitarian philosopher James Mill (the father of John Stuart Mill) wrote in his Elements of Political Economy: "The result to be aimed at is to secure to the great body of the people all the happiness which is capable of being derived from the matrimonial union, (while) preventing the evils which the too rapid increase of their numbers would entail. The progress of legislation, the improvement of the education of the people, and the decay of superstition will, in time, it may be hoped, accomplish the difficult task of reconciling these important objects."

This somewhat vague advocacy of birth control was made much more explicit by the trade union leader Francis Place (1771-1854). In 1822 Place published, at considerable risk to himself, a pamphlet entitled To the Married of Both Sexes of the Working People. Place's pamphlet contains the following passages:

"It is a great truth, often told and never denied, that when there are too many working people in any trade or manufacture, they are worse paid than they ought to be paid, and are compelled to work more hours than they ought to work. When the number of working people in any trade or manufacture has for some years been too great, wages are reduced very low, and the working people become little better than slaves." "When wages have thus been reduced to a very small sum, working people can no longer maintain their children as all good and respectable people wish to maintain their children, but are compelled to neglect them; - to send them to different employments; - to Mills and Manufactories, at a very early age."

"The miseries of these poor children cannot be described, and need not be described to you, who witness them and deplore them every day of your lives."

"The sickness of yourselves and your children, the privation and pain and premature death of those you love but cannot cherish as you wish, need only be alluded to. You know all these evils too well." "And what, you will ask, is the remedy? How are we to avoid these miseries? The answer is short and plain: the means are easy. Do as other people do, to avoid having more children than they wish to have, and can easily maintain."

Place's pamphlet then goes on to describe very explicitly the sponge method of contraception. "What is to be done is this. A piece of soft sponge is tied by a bobbin or penny ribbon, and inserted just before intercourse takes place. Many tie a sponge to each end of a ribbon, and they take care not to use the same sponge again until it has been washed. If the sponge be large enough, that is, as large as a green walnut, or a small apple, it will prevent conception.... without diminishing the pleasures of married life..."

In 1832, Dr. Charles Knowlton, a Boston physician, published a book entitled *The Fruits of Philosophy, or the Private Companion of Young Married People.* It reviewed the various methods of birth control then available, and it pointed out that in order to be reliable, the sponge method required the use of a saline douching solution. This small book was reprinted in England and sold for a number of years without opposition. However, in 1876, the book was classified as obscene under a new law, and a bookseller was sentenced to two years in prison for selling it. The feminist leader, Annie Besant, and the liberal politician, Charles Bradlaugh, then provoked a new trial by selling the book themselves. They sent a polite letter to the magistrates announcing when and where they intended to sell Knowlton's book, and asking to be arrested. The result was a a famous trial, at which the arguments of Malthus were quoted both by the judge and by the defense. The result of trial was inconclusive, however: Annie Besant and Charles Bradlaugh were acquitted, but Knowlton's book was held to be obscene.

As the nineteenth century progressed, birth control gradually came to be accepted in England, and the average number of children per marriage fell from 6.16 in 1860 to 4.13 in 1890. By 1915 this figure had fallen to 2.43. Because of lowered population pressure, combined with the growth of trade unions and better social legislation, the condition of England's industrial workers improved; and under the new conditions, Ricardo's Iron Law of Wages fortunately no longer seemed to hold.

Trade unions and child labor laws

The battle to establish trade unions was not won easily. At the start of the 19th century, many countries had laws prohibiting organizing unions, and these invoked penalties up to and including death. In England, the Reform Act of 1832 made unions legal, but nevertheless in 1834, six men from Dorset who had formed the "Friendly Society of Agricultural Workers" were arrested and sentenced to a seven years' transportation to Australia. An obscure law from 1797 was invoked, which prohibited swearing secret oaths. This they had in fact done, but their main crime seems to have been refusing to work for less than 10 shillings a week. Despite bitter opposition, trade unions gradually developed both in England and in other industrial countries.

One of the important influences for reform was the Fabian Society, founded in London

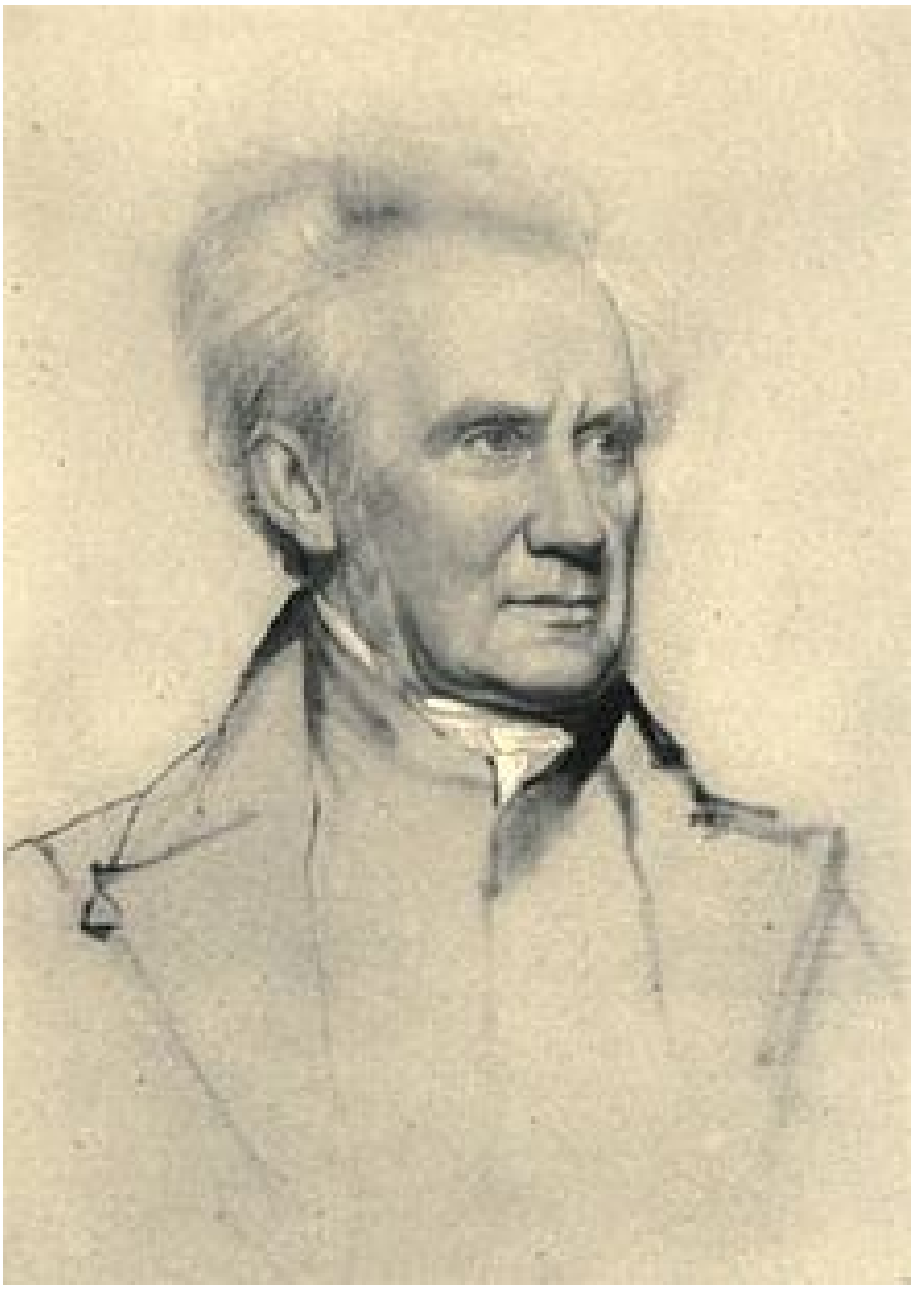

Figure B.3: **Francis Place (1771-1854), was a trade union leader and reformer who was anxious to improve the lives of workers. His political activities brought him into contact with William Godwin, James Mill, John Stuart Mill, Robert Owen and Jeremy Bentham. He courageously advocated birth control at a time when it was dangerous to do so.**

Figure B.4: **Annie Besant (1847-1933). She and the Liberal politician Charles Bradlaugh sent a polite letter to the magistrates announcing when and where they intended to sell Knowlton's book on birth control methods, and asking to be arrested. The result was a a famous trial, at which the arguments of Malthus were quoted both by the judge and by the defense. The result of trial was inconclusive, however: Annie Besant and Charles Bradlaugh were acquitted, but Knowlton's book was held to be obscene.**

Figure B.5: **Marie Stopes (1880-1958). She founded the first birth control clinic in Britain, and authored the controversial sex manual *Married Love*. Stopes disapproved of abortion and believed that birth control methods should be used to make abortion unnecessary. She edited the newsletter *Birth Control News*, which gave explicit practical advice.**

in 1884. The group advocated gradual rather than revolutionary reform (and took its name from Quintus Fabius Maximus, the Roman general who defeated Hannibal's Carthaginian army by using harassment and attrition rather than head-on battles). The Fabian Society came to include a number of famous people, including Sydney and Beatrice Webb, George Bernard Shaw, H.G. Wells, Annie Besant, Leonard Woolf, Emmeline Pankhurst, Bertrand Russell, John Maynard Keynes, Harold Laski, Ramsay MacDonald, Clement Attlee, Tony Benn and Harold Wilson. Jawaharlal Nehru, India's first Prime Minister, was greatly influenced by Fabian economic ideas.

The group was instrumental in founding the British Labour Party (1900), the London School of Economics and the New Statesman. In 1906, Fabians lobbied for a minimum wage law, and in 1911 they lobbied for the establishment of a National Health Service.

Adam Smith had praised division of labor as one of the main elements in industrial efficiency, but precisely this aspect of industrialism was criticized by Thomas Carlyle (1795-1891), John Ruskin (1819-1900) and William Morris (1834-1896). They considered the numbingly repetitive work of factory laborers to be degrading, and they rightly pointed out that important traditions of design were being lost and replaced by ugly mass produced artifacts. The Arts and Crafts movement founded by Ruskin and Morris advocated cooperative workshops, where creative freedom and warm human relationships would make work rewarding and pleasant. In several Scandinavian countries, whose industrialization came later than England's, efforts were made to preserve traditions of design. Hence the present artistic excellence of Scandinavian furniture and household articles.

Through the influence of reformers, the more brutal aspects of Adam Smith's economic model began to be moderated. Society was learning that free market mechanisms alone do not lead to a happy and just society. In addition, ethical and ecological considerations and some degree of governmental regulation are also needed.

The Reform Movement aimed at social goals, but left ecological problems untreated. Thus our economic system still does not reflect the true price to society of environmentally damaging activities. For example, the price of coal does not the reflect the cost of the environmental damage done by burning it. This being so, our growth-worshiping economic system of today thunders ahead towards an environmental mega-catastrophe, as we will see in the next chapter.

B.2 Birth control in the United States

The Comstock Laws

Anthony Comstock (1844-1915) was a United States Postal Inspector, which is to say that he was the head of a department of the US Postal Service that had the responsibility of preventing the mail from being used for illegal or immoral purposes. Unfortunately, in his view, this included any information or materials related to birth control.

According to the Wikipedia article about him, "In 1873, Comstock created the New York Society for the Suppression of Vice, an institution dedicated to supervising the morality of the public. Later that year, Comstock successfully influenced the United States Congress to pass the Comstock Law, which made illegal the delivery by U.S. mail, or by other modes of transportation, of 'obscene, lewd, or lascivious' material, as well as prohibiting any methods of production or publication of information pertaining to the procurement of abortion, the prevention of conception and the prevention of venereal disease.

"During his career, Comstock clashed with Emma Goldman and Margaret Sanger. In her autobiography, Goldman referred to Comstock as the leader of America's 'moral eunuchs'. Comstock had numerous enemies, and in later years his health was affected by a severe blow to the head from an anonymous attacker. He lectured to college audiences and wrote newspaper articles to sustain his causes. Before his death, Comstock attracted the interest of a young law student, J. Edgar Hoover, who was interested in his causes and methods.

"Comstock is also known for his opposition to suffragists Victoria Woodhull and Tennessee Celeste Claflin, and those associated with them. The men's journal The Days' Doings had popularized images of the sisters for three years and was instructed by its editor (while Comstock was present) to stop producing lewd images. Comstock also took legal action against the paper for advertising contraceptives. When the sisters published an expose of an adulterous affair between Reverend Henry Ward Beecher and Elizabeth Tilton, he had the sisters arrested under laws forbidding the use of the postal service to distribute 'obscene material'

"Comstock's ideas of what might be 'obscene, lewd, or lascivious' were quite broad.

During his time of greatest power, even some anatomy textbooks were prohibited from being sent to medical students by the United States Postal Service.

"Through his various campaigns, he destroyed 15 tons of books, 284,000 pounds of plates for printing 'objectionable' books, and nearly 4,000,000 pictures. Comstock boasted that he was responsible for 4,000 arrests and claimed he drove fifteen persons to suicide."

"In 1915, architect William Sanger was charged under the New York law against disseminating contraceptive information.[24] His wife Margaret Sanger was similarly charged in 1915 for her work The Woman Rebel. Sanger circulated this work through the U.S. postal service, effectively violating the Comstock Law. On appeal, her conviction was reversed on the grounds that contraceptive devices could legally be promoted for the cure and prevention of disease.

"The prohibition of devices advertised for the explicit purpose of birth control was not overturned for another eighteen years. During World War I, U.S. servicemen were the only members of the Allied forces sent overseas without condoms.

"In 1932, Sanger arranged for a shipment of diaphragms to be mailed from Japan to a sympathetic doctor in New York City. When U.S. customs confiscated the package as illegal contraceptive devices, Sanger helped file a lawsuit. In 1936, a federal appeals court ruled in United States v. One Package of Japanese Pessaries that the federal government could not interfere with doctors providing contraception to their patients.

"Griswold v. Connecticut (1965) struck down one of the remaining contraception Comstock laws in Connecticut and Massachusetts. However, Griswold only applied to marital relationships. Eisenstadt v. Baird (1972) extended its holding to unmarried persons as well."

Margaret Sanger is widely regarded as the founder of the modern birth control movement. She was born in 1879 in New York State, to Irish-American parents. Margaret Sanger's mother, Anne Higgens, went through 18 pregnancies, resulting in 11 live births, before dying, exhausted, at the age of 49. Of the 11 surviving children, Margaret was the sixth, and she spent much of her youth caring for her younger siblings. Nevertheless, with the help of her two older sisters, she attended Claverack College and the Hudson River Institute. She became a nurse, and in 1902 she married William Sanger, who was both a socialist and a successful architect.

In the years 1911-1912, Margaret Sanger wrote a series of articles for the magazine The New York Call entitled *What Every Mother Should Know* and in 1912-1913 *What Every Girl Should Know*. Both of these series appeared as books in 1916. Many New York readers were outraged by the frankness of the articles, but many others praised them for their honesty. One reader stated that the articles contained "a purer morality than whole libraries full of hypocritical cant about modesty".

Margaret Sanger's work as a nurse among poor immigrant women convinced her that birth control information was urgently needed to avoid excessive family size and deaths from the consequences of back-street abortions. Throughout her career, Sanger disapproved of abortion, and believed that preventative birth control is the only practical way to avoid it.

One of her patients, Sadie Sachs, died after a self-induced abortion. Remembering this

Figure B.6: **Anthony Comstock (1844-1915). He boasted that he was responsible for 4,000 arrests and claimed he drove fifteen persons to suicide. Through his various campaigns, he destroyed 15 tons of books, 284,000 pounds of plates for printing 'objectionable' books, and nearly 4,000,000 pictures.**

Figure B.7: **Emma Goldman (1869-1940). She was arrested several times for illegally distributing information on birth control. Wikipedia states that "Her writing and lectures spanned a wide variety of issues, including prisons, atheism, freedom of speech, militarism, capitalism, marriage, free love, and homosexuality."**

Figure B.8: **Margaret Sanger (1879-1966) is considered to be the founder of the modern birth control movement. Defying threats of arrest, she founded the first birth control clinic in America as well as an organization that developed into the Planned Parenthood Federation of America. In 1925 Sanger organized the Sixth International Neo-Malthusian Birth Control Conference. From 1952 to 1959, she served as President of the International Planned Parenthood Federation.**

event, Margaret Sanger said later: "I threw my nursing bag in the corner and announced ... that I would never take another case until I had made it possible for working women in America to have the knowledge to control birth".

B.3 China and India

Table 2.1 shows the population of China at the start of various dynasties. In 125 AD, at the start of the Eastern Han Dynasty, the population was 48,690,789. The precision of this figure is surprising, and it is perhaps the result of the strength of the central government of China even at that early date. As seen in Table 2.1 the population seems to have fallen again, probably to famine and war. Fear of these terrible Malthusian forces explains the Chinese preference for a strong central government. At the start of the Qing dynasty in the 17th century, the population of China began to increase rapidly, probably because of improved flood control and irrigation methods. By 1901. the population of China had reached 426,447,325.

Figure 2.19 shows the growth of Chinese population between 1960 and the present. China's population continues to increase, dispute the government's one-child policy, and today the country has approximately 1.4 billion people. China's rate of population growth is currently only 0.59%.

The post-1949 Chinese government leaders at first viewed population growth as an asset. However, worries about falling water tables and the future availability of fresh water for agriculture, as well as the realization that rapid population growth would block economic development soon produced a policy switch; and the Chinese government began to strongly support both birth control and late marriage.

Since 1979, the Chinese government has advocated a one-child policy for both rural and urban areas. However, this policy admits many exceptions and has been most effective in cities, where the government is able to exert it power by giving apartments only to families with a single child. In 2016, the one-child policy began to be phased out.

Figure B.9: **The one-child policy: A Chinese mother and her only child at a market in Jiayuguan.**

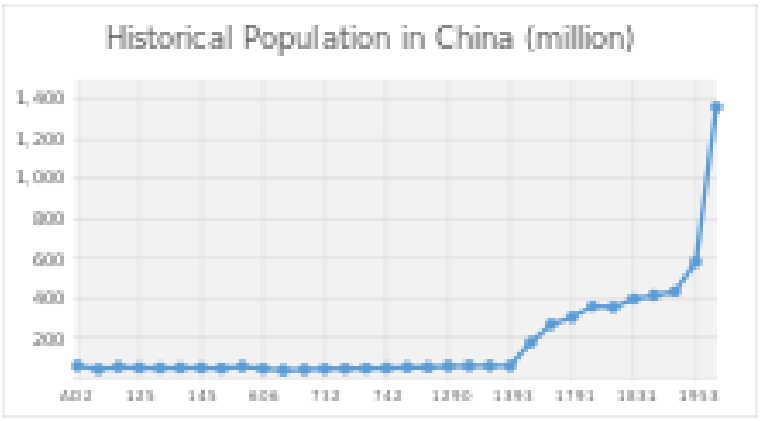

Figure B.10: **Historical estimates of China's population, in millions, from AD 2 until the present. After Ming and earlier period of Qing dynasty founded population moved around 100 million to 150 million until 1700s. In the period between 1749 and 1851, the population doubled in a century. During 1960-2015, the population doubled to nearly 1.4 billion .**

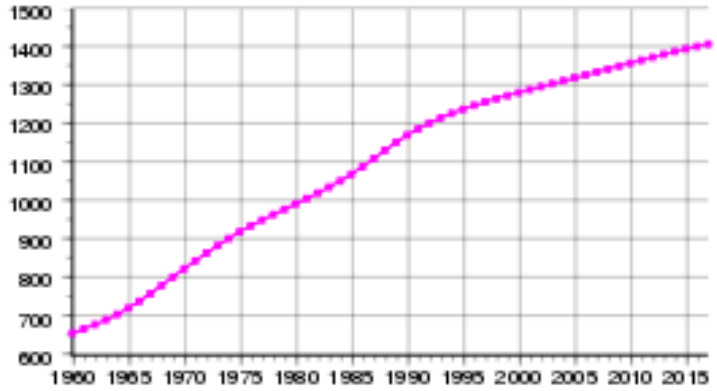

Figure B.11: **This graph shows the population growth of China, in billions, since 1900. Despite China's one-child policy, the country's population continues to grow because of exceptions to the policy and because so many young people are now reaching reproductive age.**

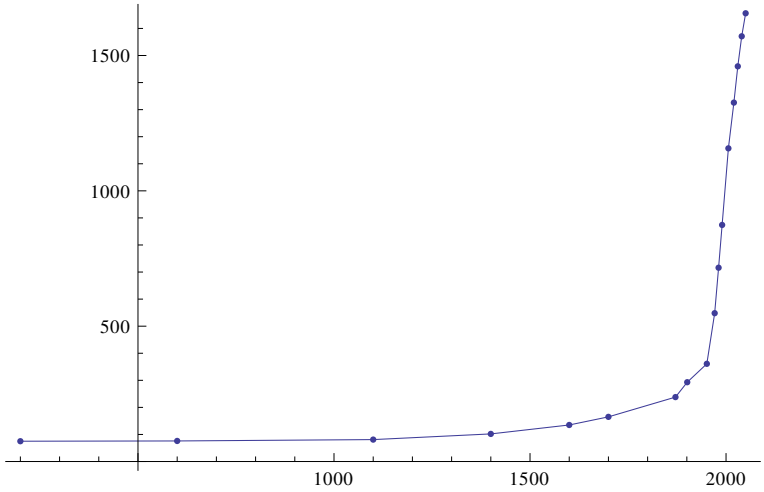

Figure B.12: **The historical and projected population of India as a function of time, from 200 AD to 2050, based on data from the Wikipedia article on *Demographics of India*. If the projections hold, there will be 1.4 billion people in India by 2050, making it the most populous country in the world. However, there is a danger that death rates may rise sharply because of famine and because of deaths due to rising temperatures.**

Table B.1: **China's Dynastic Census Data**

Dynasty	Date (AD)	Households	Population
Eastern Han	125	9,647,838	48,690,789
Western Jin	280	2,458,480	16,163,863
Tang	639	3,120,151	13,252,894
Song	1003	6,864,160	14,278,040
Ming	1398	10,699,399	58,323,933
Qing	1661	not recorded	58,323,933
Qing	1722	not recorded	103,053,992
Qing	1812	not recorded	333,700,560
Qing	1901	not recorded	426,447,325

Table B.2: **World Population in 2050 (in billions)**

Region	2000	2050	growth
Asia	3.73	5.26	41%
Africa	0.82	2.53	209%
Europe	0.73	0.72	-2%
Latin America	0.53	0.78	48%
North America	0.31	0.43	39%
Oceania	0.03	0.06	84%
World	6.14	9.77	60%

Figure B.13: **This figure shows China's economic growth rate in recent years. The doubling time for a quantity growing at the rate of 6.8% per year is only 11 years. This high rate of economic growth, compounded by China's still-growing population, cannot continue without producing an ecological catastrophe, the beginnings of which can already be seen in China.**

B.4 Population projections in Africa

Wikipedia's article on *Projections of Population Growth* states that "By 2070, the bulk of the world's population growth will take place in Africa: of the additional 2.4 billion people projected between 2015 and 2050, 1.3 billion will be added in Africa, 0.9 billion in Asia and only 0.2 billion in the rest of the world. Africa's share of global population is projected to grow from 16% in 2015 to 25% in 2050 and 39% by 2100, while the share of Asia will fall from 60% in 2015 to 54% in 2050 and 44% in 2100. The strong growth of the African population will happen regardless of the rate of decrease of fertility, because of the exceptional proportion of young people already living today. For example, the UN projects that the population of Nigeria will surpass that of the United States by 2050."

"During 2005-2050, twelve countries are expected to account for half of the world's projected population increase: India, China, United States, Indonesia, Nigeria, Pakistan, Brazil, Democratic Republic of the Congo, Ethiopia, Philippines, Mexico and Egypt, listed according to the size of their contribution to population growth."

The predictions shown in Table 2.2, especially the prediction that the population of Africa will be 2.53 billion people, raise some worrying questions. It seems likely that because of climate change, failure of the West African monsoon, desertification, and sale of African agricultural land to rich countries such China and Saudi Arabia, the food available to the people of Africa will diminish rather than increasing. Can the population of Africa really increase by 209% by 2050? Or will this be prevented by the terrible Malthusian forces of famine, disease and war? In some parts of Africa famine is already present.

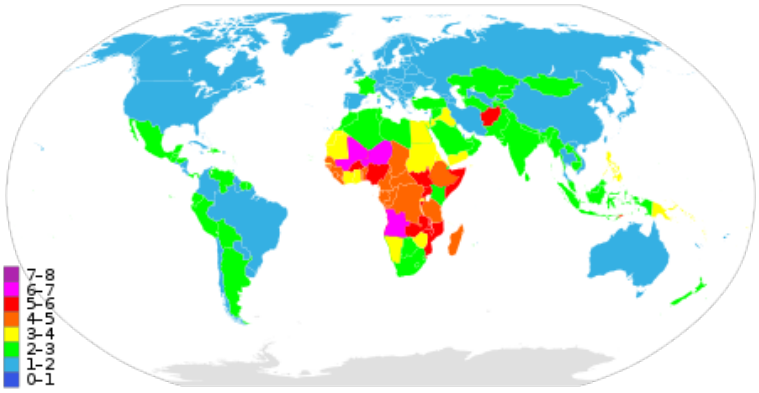

Figure B.14: **A map from the Wikipedia article showing global fertility rates in 2015. The highest fertility rates (purple, 7-8 children per woman-life) occur in Africa.**

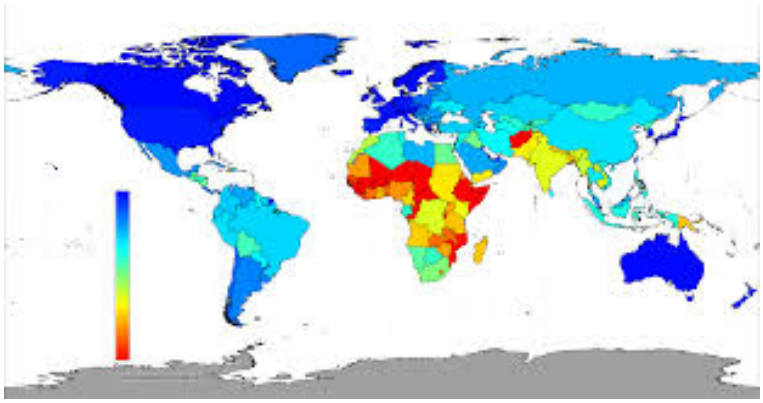

Figure B.15: **A map showing the human development index (HDI) in various parts of the world. The index is based on educational levels, life expectancy, and GDP per capita. It can be seen that regions of high fertility generally have low HDI values.**

B.5 What is the future of megacities?

A transformation in cities is going on. Over 80% of the people on the planet today are living in cities. Over 100 new cities will be created within 25 years in China alone. Over 20 new Megacities will redefine the consumer marketplace and society. Most of these cities of over 8 million people each will be in the developing world. With the huge migration to cities of the global population, what challenges will these cities face? What are the opportunities and risks? How should global organizations prepare for the future of cities?

Transition Towns

The Transition Town Movement of today is a response to the end of the fossil fuel era and the threat of economic collapse. It can be thought of as a modern branch of the Cooperative Movement. In 2006, the Transition Town of Totnes in Devon, England was the first to use this name, which implied a transition from globalism, consumerism and growth to a sustainable, local and self-sufficient economy. The ideal was to produce locally all the necessary food for the town, and as much of other necessities as possible. In this way, the energy expenditures involved in transportation could be avoided.

Today there are more than a thousand Transition Towns and they are located in 43 countries. Many of them have local currencies which are legal tender within the town. If the pioneers of this movement are right in saying that this is the only sustainable model for the future, we may wonder whether mega-cities will be able to survive in the long-term future.[1]

Gandhi's vision of India's future

Gandhi tried to reconstruct the crafts and self-reliance of village life that he felt had been destroyed by the colonial system. "I would say that if the village perishes, India will perish too", he wrote, "India will be no more India. Her own mission in the world will get lost. The revival of the village is only possible when it is no more exploited. Industrialization on a mass scale will necessarily lead to passive or active exploitation of the villagers as problems of competition and marketing come in. Therefore we have to concentrate on the village being self-contained, manufacturing mainly for use. Provided this character of the village industry is maintained, there would be no objection to villagers using even the modern machines that they can make and can afford to use. Only they should not be used as a means of exploitation by others."

"You cannot build nonviolence on a factory civilization, but it can be built on self-contained villages... Rural economy as I have conceived it, eschews exploitation altogether, and exploitation is the essence of violence... We have to make a choice between India of

[1] https://en.wikipedia.org/wiki/Degrowth
http://commondreams.org/views/2015/07/31/we-are-all-greece
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Table B.3: **The World's Largest Cities in 2016**

Rank	Name	Country	Population
1	Tokyo	Japan	38,140,000
2	Shanghai	China	34,000,000
3	Jakarta	Indonesia	31,500,000
4	Delhi	India	27,200,000
5	Seoul	Korea	25,600,000
6	Guangzhou	China	25,000,000
7	Beijing	China	24,900,000
8	Manila	Philippines	24,100,000
9	Mumbai	India	23,900,000
10	New York City	United States	23,876,155
11	Shenzhen	China	23,300,000
12	Sao Paolo	Brazil	21,242,939

Figure B.16: **Totnes, Devon, England: a transition town.**

the villages that are as ancient as herself and India of the cities which are a creation of foreign domination..."

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Appendix C

AN EXPLOSION OF TECHNOLOGY

We have seen how the development of printing in Europe produced a brilliant, chainlike series of scientific discoveries. During the 17th century, the rate of scientific progress gathered momentum, and in the 18th and 19th centuries, the practical applications of scientific knowledge revolutionized the methods of production in agriculture and industry.

During the Industrial Revolution, feudal society, with its patterns of village life and its traditional social obligations, was suddenly replaced by a money-dominated society whose rules were purely economic, and in which labor was regarded as a commodity. The changes produced by the industrial revolution at first resulted in social chaos - enormous wealth in some classes of society, and great suffering in other classes; but later, after the appropriate social and political adjustments had been made, the improved methods of production benefited all parts of society in a more even way.

C.1 Development of the steam engine

The discovery of atmospheric pressure

Early steam engines made use of the pressure of the atmosphere, and in fact it was the discovery of atmospheric pressure that led to the invention of the steam engine. Aristotle had maintained "nature abhors a vacuum", but this doctrine was questioned by the Italian physicist Evangelista Torricelli (1608-1647), who invented the barometer in 1643.

Pump makers working for the Grand Duke of Tuscany had found that suction pumps were unable to raise water to heights greater than 10 meters (in today's units). Attempting to understand why this should be the case, Torricelli filled an approximately 1-meter-long glass tube with mercury, which is 14 times denser than water. The tube was sealed at one end, and open at the other. He then immersed the open end in a dish of mercury, and raised the sealed end, so that the tube was in a vertical position. Part of the mercury flowed out of the tube into the dish, leaving a 76-centimeter-high column of mercury, and

24 centimeters of empty space at the top. The empty space contained what we now call a Torricellian vacuum.

This experiment enabled Torricelli to understand why the Grand Duke's suction pumps were unable to raise water to a height greater than 10 meters. Torricelli realized that both the 10 meter column of water (the maximum that could be achieved), and the (equally heavy) 76 centimeter column of mercury, were held in place by the weight of the atmosphere, which they exactly balanced. Later experiments soon demonstrated that the height of the column of mercury in Torricelli's barometer depended on the weather, and on height above sea level. Summarizing his experiments, Torricelli wrote: "We live submerged at the bottom of an ocean of elementary air, which is known by incontestable experiments to have weight."

Torricelli's experiments marked the start of period where, throughout Europe, much interest was focused on experiments with gases. In 1650 Otto von Guericke, the Mayor of Magdeburg Germany, invented the first vacuum pump. In a dramatic experiment, performed in 1663 in the presence of Frederick Wilhelm I of Brandenburg, von Guericke's assistants fitted two large copper hemispheres together, after the joining surfaces had been carefully greased to make the junction airtight. Von Guericke's pump was then used to evacuate the volume within the hemispheres. To the amazement of the watching crowd, a team of 24 horses, 12 on each side, strained at the hemispheres but failed to separate them. Von Guericke explained that it was the pressure of the atmosphere that held the hemispheres so tightly together, and he demonstrated that when air was allowed to enter the interior volume, the hemispheres could be separated without effort.

Steam engines using atmospheric pressure

Continuing the vogue for experiments with gases and pumps that was sweeping across Europe, Edward Somerset, the 2nd Marquess of Worcester, designed steam-powered pumps to bring water from wells to fountains. He published the designs for his engines in 1663, and he may have installed pumps built according to these designs at Vauxhall House in London. In the 1680's a number of steam-powered pumps were constructed for Louis XIV of France by Sir Samuel Morland (1625-1695), who lived in Vauxhall and may have been influenced by Somerset's ideas.

Meanwhile, in France, the physicist Denis Papin (1647-1712) had become interested in the motive force of steam. Together with Gottfried Leibniz he invented the pressure cooker, and he also invented designs for steam engines. Some of Papin's steam engine designs were presented to the Royal Society between 1707 and 1712, without acknowledgment or payment, and this caused Papin to complain bitterly. He died soon afterward.

In 1698, the English inventor Thomas Savery (1650-1715) patented a steam engine for pumping water. It had no piston, but used condensing steam and atmospheric pressure to bring up the water by means of a siphon principle. It was therefore useless for pumping water from very deep mines, although Savery described it as the "Miner's Friend". Savery's design was so similar to Somerset's that it was probably a direct copy.

The ironmonger Thomas Newcomen's "atmospheric-engine" of 1712 proved to be much

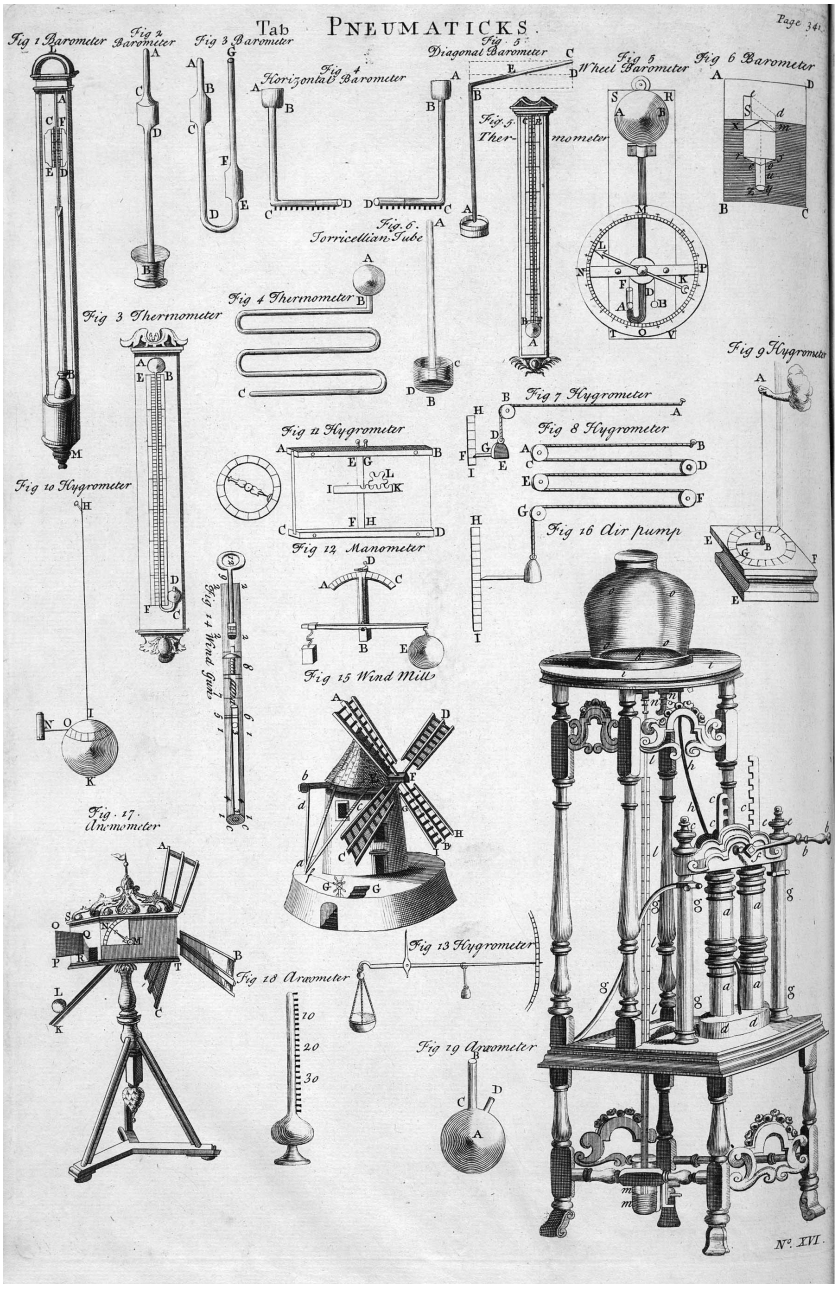

Figure C.1: **"Table of Pneumaticks" (1728).**

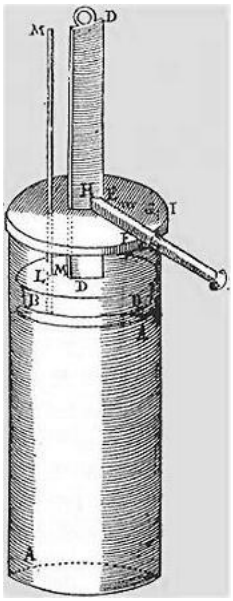

Figure C.2: **The French physicist Papin's design for a steam engine (1690).**

more practical for pumping water from the deep mines of Cornwall. Newcomen was forced to go into a partnership with Savery because of the latter's patent, and he also used some of Papin's ideas. An important feature of Newcomen's engine was a beam that transmitted power from the working piston to a pump at the base of the mineshaft. In Newcomen's engine, steam entered the cylinder, driving the piston upward. A jet of water was then sprayed into the interior of the cylinder, condensing the steam and allowing atmospheric pressure to drive the piston down. Early models of the engine operated slowly, and the valves were opened and closed by hand. Later, the opening and closing of the valves was performed automatically by means of the "potter cord". According to legend this device is named after a boy, Humphrey Potter, who in 1713 had been given the job of opening and closing the valves. Wishing to play with his friends, he invented the automatic mechanism.

The main problem with Newcomen's engine was that its fuel use was enormously wasteful. This was because, with every cycle, the cylinder was cooled by water, and then heated again by steam.

At Glasgow University, where Adam Smith was Professor of Moral Philosophy, there was a shop where scientific instruments were made and sold. The owner of the shop was a young man named James Watt (1736-1819), who came from a family of ship builders and teachers of mathematics and navigation. Besides being an extremely competent instrument maker, Watt was a self-taught scientist of great ability, and his shop became a meeting place for scientifically inclined students.

James Watt tried to repair the university's small-scale model of the Newcomen engine, but he failed to make it work well. He could see that it was extraordinarily inefficient in its use of fuel, and he began making experiments to find out why it was so wasteful. James Watt quickly found the answer: The engine was inefficient because of the large amounts of

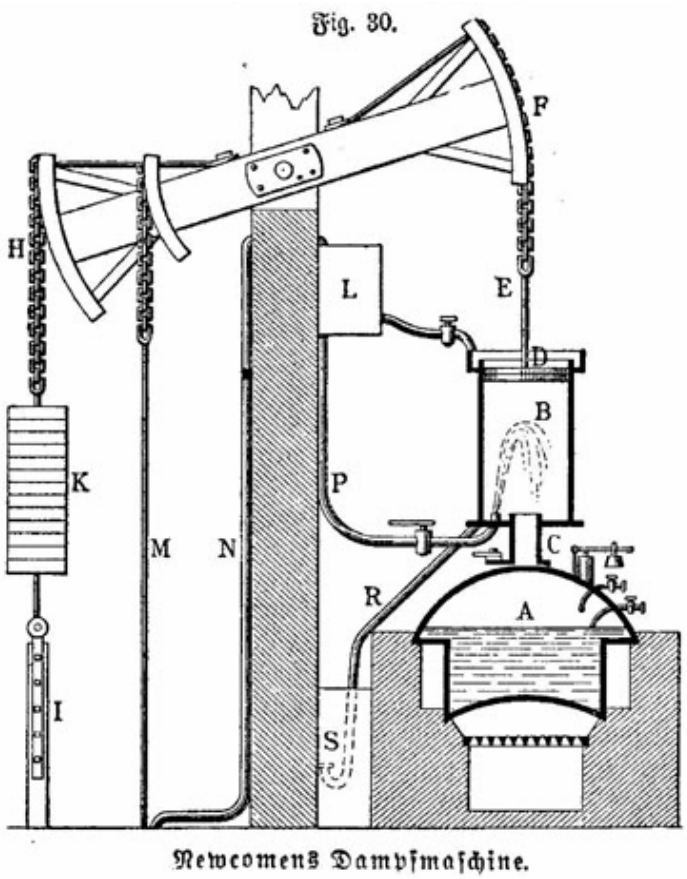

Figure C.3: **Newcomen's steam engine.**

energy needed to heat the iron cylinder. In 1765, Watt designed an improved engine with a separate condenser. The working cylinder could then be kept continuously hot.

To have an idea for a new, energy-saving engine was one thing, however, and to make the machine practical was another. James Watt had experience as an instrument maker, but no experience in large-scale engineering. However, Watt formed a partnership with Matthew Boulton, who was the most talented and progressive manufacturer in England.

Boulton was more interested in applying art and science to manufacturing than he was in simply making money. His idea was to bring together under one roof the various parts of the manufacturing process which had been scattered among many small workshops by the introduction of division of labor. He believed that improved working conditions would result in an improved quality of products.

With these ideas in mind, Matthew Boulton built a large mansion-like house on his property at Soho, outside Birmingham, and installed in it all the machinery necessary for the complete production of a variety of small steel products. Because of his personal charm, and because of the comfortable working conditions at the Soho Manufactory, Boulton was able to attract the best and most skillful craftsmen in the region; and by 1765, the number of the staff at Soho had reached 600.

At this point, Erasmus Darwin (the grandfather of Charles Darwin) introduced James Watt to Matthew Boulton, and they formed a partnership for the development of the steam engine. The high quality of craftsmanship and engineering skill which Matthew Boulton was able to put at Watt's disposal allowed the young inventor to turn his great idea into a reality. However, progress was slow, and the original patent was running out.

Boulton skillfully lobbied in Parliament for an extension of the patent and, as James Watt put it, "Mr. Boulton's amiable and friendly character, together with his fame as an ingenious and active manufacturer procured me many and very active friends in both houses of Parliament".

In 1775, the firm of Boulton and Watt was granted an extension of the master steam engine patent until 1800. From a legal and financial standpoint, the way was now clear for the development of the engine; and a major technical difficulty was overcome when the Birmingham ironmaster and cannon-maker, John Wilkinson, invented a method for boring large cylinders accurately by fixing the cutting tool to a very heavy and stable boring shaft.

By 1780, Boulton and Watt had erected 40 engines, about half of which pumped water from the deep Cornish tin mines. Even their early models were at least four times as efficient as the Newcomen engine, and Watt continually improved the design. At Boulton's urging, James Watt designed rotary engines, which could be used for driving mills; and he also invented a governor to regulate the speed of his engines, thus becoming a pioneer of automation. By the time its patent of the separate condenser had run out in 1800, the firm of Boulton and Watt had made 500 engines. After 1800, the rate of production of steam engines became exponential, and when James Watt died in 1819, his inventions had given employment, directly or indirectly, to an estimated two million people.

The Soho manufactory became an almost obligatory stop on any distinguished person's tour of England. Samuel Johnson, for example, wrote that he was received at Soho with great civility; and Boswell, who visited Soho on another occasion, was impressed by "the vastness and contrivance" of the machinery. He wrote that he would never forget Matthew Boulton's words to him as they walked together through the manufactory: "I sell here, Sir, what all the world desires to have - Power!"

C.2 Working conditions

Both Matthew Boulton and James Watt were model employers as well as pioneers of the factory system. Boulton had a pension scheme for his men, and he made every effort to insure that they worked under comfortable conditions. However, when he died in 1809, the firm of Boulton and Watt was taken over by his son, Matthew Robbinson Boulton, in partnership with James Watt Jr. The two sons did not have their fathers' sense of social responsibility; and although they ran the firm very efficiently, they seemed to be more interested in profit-making than in the welfare of their workers.

A still worse employer was Richard Arkwright (1732-1792), who held patents on a series of machines for carding, drawing and spinning silk, cotton, flax and wool. He was a rough, uneducated man, who rose from humble origins to become a multimillionaire by driving

Figure C.4: **Manchester in the 1840's.**

himself almost as hard as he drove his workers. Arkwright perfected machines (invented by others) which could make extremely cheap and strong cotton thread; and as a result, a huge cotton manufacturing industry grew up within the space of a few years. The growth of the cotton industry was especially rapid after Arkwright's patent expired in 1785.

Crowds of workers, thrown off the land by the Enclosure Acts and by the Clearances in Scotland, flocked to the towns, seeking work in the new factories[1]. Wages fell to a near-starvation level, hours of work increased, and working conditions deteriorated. Dr. Peter Gaskell, writing in 1833, described the condition of the English mill workers as follows:

"The vast deterioration in personal form which has been brought about in the manufacturing population during the last thirty years... is singularly impressive, and fills the mind with contemplations of a very painful character... Their complexion is sallow and pallid, with a peculiar flatness of feature caused by the want of a proper quantity of adipose substance to cushion out the cheeks. Their stature is low - the average height of men being five feet, six inches... Great numbers of the girls and women walk lamely or awkwardly... Many of the men have but little beard, and that in patches of a few hairs... (They have) a spiritless and dejected air, a sprawling and wide action of the legs..."

"Rising at or before daybreak, between four and five o'clock the year round, they swallow a hasty meal or hurry to the mill without taking any food whatever... At twelve

[1]During the Highland Clearances, families that had farmed the land for generations were violently forced to leave their houses, which were then burned to prevent return. The land was afterward used as pasturage for sheep, which had been found to be more profitable. Donald McLeod, a crofter (small farmer) in Sutherland, has left the following account of the Clearances in his district: "The consternation and confusion were extreme. Little or no time was given for the removal of persons or property; the people striving to remove the sick and helpless before the fire should reach them; next, struggling to save the most valuable of their effects. The cries of the women and children, the roaring of the affrighted cattle, hunted at the same time by the yelling dogs of the shepherds amid the smoke and fire, altogether presented a scene that completely baffles description - it required to be seen to be believed... The conflagration lasted six days, until the whole of the dwellings were reduced to ashes or smoking ruins."

Figure C.5: **London during the industrial revolution.**

o'clock the engine stops, and an hour is given for dinner... Again they are closely immured from one o'clock till eight or nine, with the exception of twenty minutes, this being allowed for tea. During the whole of this long period, they are actively and unremittingly engaged in a crowded room at an elevated temperature."

Dr. Gaskell described the housing of the workers as follows:

"One of the circumstances in which they are especially defective is that of drainage and water-closets. Whole ranges of these houses are either totally undrained, or very partially... The whole of the washings and filth from these consequently are thrown into the front or back street, which, often being unpaved and cut into deep ruts, allows them to collect into stinking and stagnant pools; while fifty, or even more than that number, having only a single convenience common to them all, it is in a very short time choked with excrementous matter. No alternative is left to the inhabitants but adding this to the already defiled street."

"It frequently happens that one tenement is held by several families... The demoralizing effects of this utter absence of domestic privacy must be seen before they can be thoroughly appreciated. By laying bare all the wants and actions of the sexes, it strips them of outward regard for decency - modesty is annihilated - the father and the mother, the brother and the sister, the male and female lodger, do not scruple to commit acts in front of each other which even the savage keeps hid from his fellows."

"Most of these houses have cellars beneath them, occupied - if it is possible to find a lower class - by a still lower class than those living above them."

Figure C.6: **A child working in a South Carolina mill in 1908.**

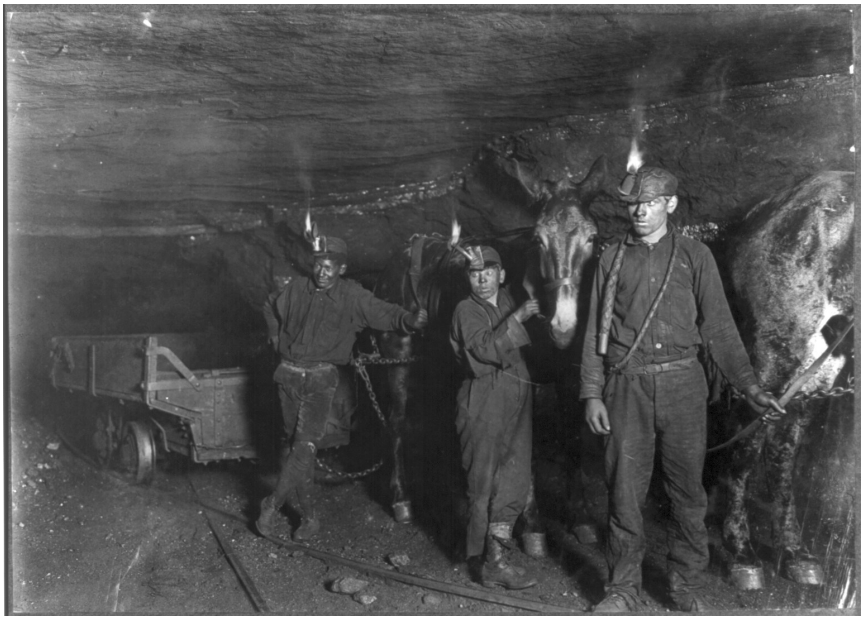

Figure C.7: **Child coal miners in Gary, West Virginia.**

The following extract from John Fielden's book, *The Curse of the Factory System* (1836), describes the condition of young children working in the cotton industry:

"It is well known that Arkwright's (so called at least) inventions took manufactures out of the cottages and farmhouses of England... and assembled them in the counties of Derbyshire, Nottinghamshire and more particularly, in Lancashire, where the newly-invented machinery was used in large factories built on the side of streams capable of turning the water wheel. Thousands of hands were suddenly required in these places, remote from towns."

"The small and nimble fingers of children being by far the most in request, the custom instantly sprang up of procuring 'apprentices' from the different parish workhouses of London, Birmingham and elsewhere... Overseers were appointed to see to the works, whose interest it was to work the children to the utmost, because their pay was in proportion to the quantity of work which they could exact."

"Cruelty was, of course, the consequence; and there is abundant evidence on record to show that in many of the manufacturing districts, the most heart-rending cruelties were practiced on the unoffending and friendless creatures... that they were flogged, fettered and tortured in the most exquisite refinement of cruelty, that they were, in many cases, starved to the bone while flogged to their work, and that even in some instances they were driven to commit suicide... The profits of manufacture were enormous; but this only whetted the appetite it should have satisfied."

The misery of factory workers in England during the early phases of the Industrial Revolution prompted the writings of Karl Marx (1818-1883) and Frederich Engels (1820-1895). Engels' book, *The condition of the Working Class in England*, was published in 1844. *The Communist Manifesto*, (*Manifest der Komunistischen Partei*), on which Marx and Engels collaborated, was published in 1848, while Marx's large book, *Das Kapital. Kritik der politischen Oekonomie* was printed in 1867.

One of the arguments which was used to justify the abuse of labor was that the alternative was starvation. The population of Europe had begun to grow rapidly for a variety of reasons: - because of the application of scientific knowledge to the prevention of disease; because the potato had been introduced into the diet of the poor; and because bubonic plague had become less frequent after the black rat had been replaced by the brown rat, accidentally imported from Asia.

It was argued that the excess population could not be supported unless workers were employed in the mills and factories to produce manufactured goods, which could be exchanged for imported food. In order for the manufactured goods to be competitive, the labor which produced them had to be cheap: hence the abuses. (At least, this is what was argued).

C.3 The slow acceptance of birth control in England

Industrialization benefited England, but in a very uneven way, producing great wealth for some parts of society, but also extreme misery in other social classes. For many, technical

progress by no means led to an increase of happiness. The persistence of terrible poverty in 19th-century England, and the combined pessimism of Ricardo and Malthus, caused Thomas Carlyle to call economics "the Dismal Science".

Fortunately, Ricardo's "Iron Law of Wages" seems to have rusted over the years. Apparently it was not an eternal law, but only a description of a passing phase of industrialism, before the appropriate social and legislative adjustments had been made. Among the changes which were needed to insure that the effects of technical progress became beneficial rather than harmful, the most important were the abolition of child labor, the development of unions, the minimum wage law, and the introduction of birth control.

Francis Place (1771-1854), a close friend of William Godwin and James Mill, was one of the earliest and most courageous pioneers of these needed changes. Place had known extreme poverty as a child, but he had risen to become a successful businessman and a leader of the trade union movement.

Place and Mill were Utilitarians, and like other members of this movement they accepted the demographic studies of Malthus while disagreeing with Malthus' rejection of birth control. They reasoned that since abortion and infanticide were already widely used by the poor to limit the size of their families, it was an indication that reliable and humane methods of birth control would be welcome. If marriage could be freed from the miseries which resulted from excessive numbers of children, the Utilitarians believed, prostitution would become less common, and the health and happiness of women would be improved.

Francis Place and James Mill decided that educational efforts would be needed to make the available methods of birth control more widely known and accepted. In 1818, Mill cautiously wrote "The great problem of a real check to population growth has been miserably evaded by all those who have meddled with the subject... And yet, if the superstitions of the nursery were discarded, and the principle of utility kept steadily in view, a solution might not be very difficult to be found."

A few years later, Mill dared to be slightly more explicit: "The result to be aimed at", he wrote in his *Elements of Political Economy* (1821), "is to secure to the great body of the people all the happiness which is capable of being derived from the matrimonial union, (while) preventing the evils which the too rapid increase of their numbers would entail. The progress of legislation, the improvement of the education of the people, and the decay of superstition will, in time, it may be hoped, accomplish the difficult task of reconciling these important objects."

In 1822, Francis Place took the considerable risk of publishing a four-page pamphlet entitled *To the Married of Both Sexes of the Working People*, which contained the following passages:

"It is a great truth, often told and never denied, that when there are too many working people in any trade or manufacture, they are worse paid than they ought to be paid, and are compelled to work more hours than they ought to work. When the number of working people in any trade or manufacture has for some years been too great, wages are reduced very low, and the working people become little better than slaves."

"When wages have thus been reduced to a very small sum, working people can no longer maintain their children as all good and respectable people wish to maintain their

children, but are compelled to neglect them; - to send them to different employments; - to Mills and Manufactories, at a very early age. The miseries of these poor children cannot be described, and need not be described to you, who witness them and deplore them every day of your lives."

"The sickness of yourselves and your children, the privation and pain and premature death of those you love but cannot cherish as you wish, need only be alluded to. You know all these evils too well."

"And what, you will ask, is the remedy? How are we to avoid these miseries? The answer is short and plain: the means are easy. Do as other people do, to avoid having more children than they wish to have, and can easily maintain."

"What is to be done is this. A piece of soft sponge is tied by a bobbin or penny ribbon, and inserted just before the sexual intercourse takes place, and is withdrawn again as soon as it has taken place. Many tie a sponge to each end of the ribbon, and they take care not to use the same sponge again until it has been washed. If the sponge be large enough, that is, as large as a green walnut, or a small apple, it will prevent conception... without diminishing the pleasures of married life..."

"You cannot fail to see that this address is intended solely for your good. It is quite impossible that those who address you can receive any benefit from it, beyond the satisfaction which every benevolent person and true Christian, must feel, at seeing you comfortable, healthy and happy."

The publication of Place's pamphlet in 1822 was a landmark in the battle for the acceptance of birth control in England. Another important step was taken in 1832, when a small book entitled *The Fruits of Philosophy or, the Private Companion of Young Married People* was published by a Boston physician named Dr. Charles Knowlton. The book contained simple contraceptive advice. It reviewed the various methods of birth control available at the time. In order for the sponge method to be reliable, Knowlton's book pointed out, use of a saline douching solution was necessary.

For a number of years, a reprinted edition of Knowlton's book was sold openly in London. However, in 1876 a new law against obscene publications was passed, and a bookseller was sentenced to two year's imprisonment for selling *The Fruits of Philosophy.* Charles Bradlaugh, a liberal politician and editor, and his friend, the feminist author Mrs. Annie Besant, then decided to sell the book themselves in order to provoke a new trial. The Chief Clerk of the Magistrates, the Detective Department, and to the City Solicitor, were all politely informed of the time and place where Charles Bradlaugh and Annie Besant intended to sell Knowlton's book, and the two reformers asked to be arrested.

In the historic trial that followed, the arguments of Malthus were used, not only by Charles Bradlaugh, who conducted his own defense, but also by the Lord Chief Justice, who instructed the jury to acquit the defendants. In the end, the jury ruled that the motives of Besant and Bradley were above reproach. However, the issue was made less clear when the jury also ruled Knowlton's book to be obscene. The enormous publicity that accompanied the trial certainly did not harm the sales of the book!

As birth control was gradually accepted in England, the average number of children per marriage fell from 6.16 in the 1860's to 4.13 in the 1890's. By 1915 the figure had

Figure C.8: **Annie Besant (1847-1933).**

fallen to 2.43. At the same time, trade unions developed, and improved social legislation was enacted. For all of these reasons, conditions improved for the English workers.

C.4 The Industrial Revolution

The development of printing in Europe produced a brilliant, chainlike series of scientific discoveries. During the 17th century, the rate of scientific progress gathered momentum, and in the 18th and 19th centuries, the practical applications of scientific knowledge revolutionized the methods of production in agriculture and industry.

The changes produced by the Industrial Revolution at first resulted in social chaos - enormous wealth in some classes of society, and great suffering in other classes; but later, after the appropriate social and political adjustments had been made, the improved methods of production benefited all parts of society in a more even way.

The Industrial Revolution marked the start of massive human use of fossil fuels. The stored energy from several hundred million years of plant growth began to be used at roughly a million times the rate at which it had been formed. The effect on human society was like that of a narcotic. There was a euphoric (and totally unsustainable) surge of growth of both population and industrial production. Meanwhile, the carbon released into the atmosphere from the burning of fossil fuels began to duplicate the conditions which led to the 5 geologically-observed mass extinctions, during each of which more than half of all living species disappeared forever.

Figure C.9: **And was Jerusalem builded here, among these dark Satanic mills?**

C.5 Technical change

We have just seen how the development of printing in Europe produced a brilliant, chainlike series of scientific discoveries. During the 17th century, the rate of scientific progress gathered momentum, and in the 18th and 19th centuries, the practical applications of scientific knowledge revolutionized the methods of production in agriculture and industry.

The changes produced by the industrial revolution at first resulted in social chaos - enormous wealth in some classes of society, and great suffering in other classes; but later, after the appropriate social and political adjustments had been made, the improved methods of production benefited all parts of society in a more even way.

There is, in fact, a general pattern which we can notice in the social impact of technology: Technical changes usually occur rapidly, while social and political adjustments take more time. The result is an initial period of social disruption following a technical change, which continues until the structure of society has had time to adjust. Thus, for example, the introduction of a money-based economy into a society which has previously been based on a pattern of traditional social duties always creates an initial period of painful disruption.

In the case of the Industrial Revolution, feudal society, with its patterns of village life and its traditional social obligations, was suddenly replaced by an industrial society whose rules were purely economic, and in which labor was regarded as a commodity. At first, the change produced severe social disruption and suffering; but now, after two centuries of social and political adjustment, the industrialized countries are generally considered to

have benefited from the change.

Cullen, Black and Watt

The two driving forces behind the Industrial Revolution were world trade and scientific discovery. During the 18th century, both these forces were especially strongly felt in Scotland and in the north-western part of England. The distilling industry in Scotland grew enormously because of world trade; and the resulting interest in what happens when liquids are vaporized and condensed produced one of the major scientific and technical developments of the Industrial Revolution.

The first step in this development was taken by William Cullen, a professor of medicine at the universities of Glasgow and Edinburgh. In a paper entitled *Of the Cold Produced by Evaporation* (1749), Cullen wrote that he had noticed that "...water and some other liquids, in evaporating, produce some degree of cold".

Cullen therefore began to make experiments in which he dipped a thermometer in and out of a liquid and observed the drop in temperature. He noticed that the effect was increased by "...moving the thermometer very nimbly to and fro in the air; or if, while the ball was wet with spirit of wine, it was blown upon with a pair of bellows". In this way, Cullen achieved a temperature 44 degrees below the freezing point of water. He next tried producing vacuums above various liquids with the help of an air pump:

"We set the vessel containing the ether", Cullen wrote, "In another a little larger, containing water. Upon exhausting the receiver and the vessel's remaining a few minutes *in vacuo*, we found the most part of the water frozen, and the vessel containing the ether surrounded with a thick crust of ice."

One of Cullen's favorite students at Edinburgh was Joseph Black (1728-1799). He became Cullen's scientific assistant, and later, in 1756, he was elected to the Chair of Medicine at Glasgow University. Continuing Cullen's work on the cold produced by evaporating liquids, Black discovered and studied quantitatively the phenomenon of latent heats, e.g., the very large quantities of heat which are necessary to convert ice into water, or to convert water into steam.

Black was led to his discovery of latent heats not only by Cullen's work, but also by his own observations on Scottish weather. Writing of the discovery, one of Black's friends at Glasgow recorded that "...since a fine winter day of sunshine did not at once clear the hills of snow, nor a frosty night suddenly cover the ponds with ice, Dr. Black was already convinced that much heat was absorbed and fixed in the water which slowly trickled from the wreaths of snow; and on the other hand, that much heat emerged from it while it was slowly changing into ice. For, during a thaw, a thermometer will always sink when removed from the air into melting snow; and during a severe frost it will rise when plunged into freezing water. Therefore in the first case, the snow is receiving heat, and in the last, the water is allowing it to emerge again."

At Glasgow University, where Joseph Black was Professor of Medicine, there was a shop where scientific instruments were made and sold. The owner of the shop was a young man

named James Watt (1736-1819), who came from a family of ship builders and teachers of mathematics and navigation. Besides being an extremely competent instrument maker, Watt was a self-taught scientist of great ability, and his shop became a meeting place for scientifically inclined students. Dr. Black was also a frequent visitor to Watt's shop, and a strong friendship formed between the professor and the highly intelligent young instrument maker.

In 1763, Glasgow University asked James Watt to repair a model of a Newcomen steam engine. This type of steam engine had been used for several years to pump water out of mines. It had a single cylinder which filled with steam so that the piston was driven to one end. Then water was sprayed into the cylinder, condensing the steam; and the vacuum drew the piston back to the other end of the cylinder, thus completing the cycle.

James Watt tried to repair the university's small-scale model of the Newcomen engine, but he failed to make it work well. He could see that it was extraordinarily inefficient in its use of fuel, and he began making experiments to find out why it was so wasteful. Because of James Watt's friendship with Joseph Black, he quickly found the answer in the phenomena of latent heats and specific heats: The engine was inefficient because of the large amounts of energy needed to convert water into steam and to heat the iron cylinder.

In 1765, Watt designed an improved engine with a separate condenser. The working cylinder could then be kept continuously hot, and the condensing steam could be returned through the boiler, so that its latent heat could be used to preheat the incoming water. To have an idea for a new, energy-saving engine was one thing, however, and to make the machine practical was another. James Watt had experience as instrument maker, but no experience in large-scale engineering.

In 1767, Watt was engaged to make a survey for a canal which was to join the Forth and the Clyde through Loch Lomond. Because of this work, he had to make a trip to London to explain the canal project to a parliamentary committee; and on the return trip he met Dr. Erasmus Darwin in Birmingham. Darwin, who was interested in steam engines, quickly recognized Watt's talent and the merit of his idea.

Erasmus Darwin (1731-1802) was the most famous physician of the period, but his interests were by no means confined to medicine. He anticipated his grandson, Charles Darwin, by developing the first reasonably well thought-out theory of evolution; and, at the time when he met James Watt he was enthusiastically trying to design a steam locomotive. His collaborators in this project were Benjamin Franklin and the pioneering Birmingham industrialist, Matthew Boulton.

In August, 1767, Erasmus Darwin wrote to Watt: "The plan of your steam improvements I have religiously kept secret, but begin to see myself some difficulties in your execution, which did not strike me when you were here. I have got another and another hobby horse since I saw you. I wish that the Lord would send you to pass a week with me, and Mrs. Watt with you; - a week, a month, a year!"

Dr. Darwin introduced James Watt to Matthew Boulton, and a famous partnership was formed. The partnership of Boulton and Watt was destined to make the steam engine practical, and thus to create a new age - an age in which humans would would rely for power neither on their own muscles nor on the muscles of slaves, but would instead control

almost unlimited power through their engines.

James Watt was lucky to meet Erasmus Darwin and to be introduced to Matthew Boulton, since Boulton was the most talented and progressive manufacturer in England - the best possible man to understand the significance of Watt's great invention and to help in its development.

Boulton

Matthew Boulton was the son of a Birmingham manufacturer, and at the age of seventeen, he had invented a type of metal buckle inlaid with glass, which proved to be extremely popular and profitable. By the time that he was twenty-one, his father had made him manager of the business. At twenty-eight, Matthew Boulton married an heiress, receiving a very large dowry. When his wife died four years later, Boulton married her younger sister, and he was given a second large fortune.

Instead of retiring from manufacturing and becoming a country gentleman, as most of his contemporaries would have done, Boulton used his wealth to try out new ideas. He tried especially to improve the quality of the goods manufactures in Birmingham. Since he was already an extremely rich man, he was more interested in applying art and science to manufacturing than he was in simply making money.

Boulton's idea was to bring together under one roof the various parts of the manufacturing process which had been scattered among many small workshops by the introduction of division of labor. He believed that improved working conditions would result in an improved quality of products.

With these ideas in mind, Matthew Boulton built a large mansion-like house on his property at Soho, outside Birmingham, and installed in it all the machinery necessary for the complete production of a variety of small steel products. Because of his personal charm, and because of the comfortable working conditions at the Soho Manufactory, Boulton was able to attract the best and most skillful craftsmen in the region; and by 1765, the number of the staff at Soho had reached 600.

Boulton continued to manufacture utilitarian goods, on which he made a profit, but he also introduced a line of goods of high artistic merit on which he gained prestige but lost money. He made fine gilt brass candelabra for both George III and Catherine the Great; and he was friendly with George III, who consulted him on technical questions.

At this point, Erasmus Darwin introduced James Watt to Matthew Boulton, and they formed a partnership for the development of the steam engine. The high quality of craftsmanship and engineering skill which Matthew Boulton was able to put at Watt's disposal allowed the young inventor to turn his great idea into a reality. However, progress was slow, and the original patent was running out.

Boulton skillfully lobbied in Parliament for an extension of the patent and, as James Watt put it, "Mr. Boulton's amiable and friendly character, together with his fame as an ingenious and active manufacturer procured me many and very active friends in both houses of Parliament".

In 1775, the firm of Boulton and Watt was granted an extension of the master steam engine patent until 1800. From a legal and financial standpoint, the way was now clear for the development of the engine; and a major technical difficulty was overcome when the Birmingham ironmaster and cannon-maker, John Wilkinson, invented a method for boring large cylinders accurately by fixing the cutting tool to a very heavy and stable boring shaft.

By 1780, Boulton and Watt had erected 40 engines, about half of which pumped water from the deep Cornish tin mines. Even their early models were at least four times as efficient as the Newcomen engine, and Watt continually improved the design. At Boulton's urging, James Watt designed rotary engines, which could be used for driving mills; and he also invented a governor to regulate the speed of his engines, thus becoming a pioneer of automation. By the time its patent of the separate condenser had run out in 1800, the firm of Boulton and Watt had made 500 engines. After 1800, the rate of production of steam engines became exponential, and when James Watt died in 1819, his inventions had given employment, directly or indirectly, to an estimated two million people.

The Soho manufactory became an almost obligatory stop on any distinguished person's tour of England. Samuel Johnson, for example, wrote that he was received at Soho with great civility; and Boswell, who visited Soho on another occasion, was impressed by "the vastness and contrivance" of the machinery. He wrote that he would never forget Matthew Boulton's words to him as they walked together through the manufactory: "I sell here, Sir, what all the world desires to have - Power!"

C.6 The Lunar Society

Matthew Boulton loved to entertain; and he began to invite his friends in science and industry to regular dinners at his home. At these dinners, it was understood by all the guests that science and philosophy were to be the topics of the conversation. This group of friends began to call themselves the "Lunar Society", because of their habit of meeting on nights when the moon was full so that they could find their way home easily afterwards.

During the early stages of the Industrial Revolution, the Lunar Society of Birmingham played a role in the development of scientific ideas which was almost as important as the role played by the Royal Society of London at the time of Isaac Newton. Among the members of this group of friends, besides Erasmus Darwin and James Watt, were the inventive and artistic pottery manufacturer, Josiah Wedgwood (the other grandfather of Charles Darwin), and the author, chemist and Unitarian minister, Joseph Priestley (1733-1804).

Joseph Priestley's interests were typical of the period: The center of scientific attention had shifted from astronomy to the newly-discovered phenomena of electricity, heat and chemistry, and to the relationship between them. Priestley, who was a prolific and popular author of books on many topics, decided to write a *History of Electricity*. He not only collected all the results of previous workers in an organized form, but also, while repeating their experiments, he made a number of original discoveries. For example, Joseph Priestley was the first to discover the inverse square law of attraction and repulsion between electrical

charges, a law which was later verified by the precise experiments of Henry Cavendish (1731-1810) and Charles Coulomb (1736-1806).

The chemistry of gases was also very much in vogue during this period. Joseph Black's medical thesis at Edinburgh University had opened the field with an elegant quantitative treatment of chemical reactions involving carbon dioxide. Black had shown that when chalk (calcium carbonate) is heated, it is changed into a caustic residue (calcium oxide) and a gas (carbon dioxide).

Black had carefully measured the weight lost by the solid residue when the gas was driven off, and he had shown that precisely the same weight was regained by the caustic residue when it was exposed to the atmosphere and reconverted to chalk. His work suggested not only that weight is conserved in chemical reactions, but also that carbon dioxide is present in the atmosphere. Black's work had initiated the use of precise weighing in chemistry, a technique which later was brought to perfection by the great French chemist, Anton Lavoisier (1743-1794).

Joseph Priestley, (who had been supplied with a large burning-glass by his brother-in-law, the wealthy ironmaster, John Wilkinson), carried out an experiment similar to Black's. He used the glass to focus the rays of the sun on a sample of what we now call red oxide of mercury. He collected the gas which was driven off, and tested its properties, recording that "...what surprized me more than I can well express was that a candle burned in this air with a remarkably vigorous flame". He also found that a mouse could live much longer in the new gas than in ordinary air.

On a trip to France, Priestley communicated these results to Anton Lavoisier, who named the gas "oxygen" and established fully its connection with combustion and respiration. At almost the same time, the Swedish chemist, Karl Wilhelm Scheele (1742-1786), discovered oxygen independently.

Joseph Priestley isolated and studied nine other new gases; and he invented the technique of collecting gases over mercury. This was much better than collecting them over water, since the gases did not dissolve in mercury. He extended Joseph Black's studies of carbon dioxide, and he invented a method for dissolving carbon dioxide in beverages under pressure, thus becoming the father of the modern soft drink industry!

The tremendous vogue for gas chemistry in the late 18th century can also be seen in the work of the eccentric multimillionaire scientist, Henry Cavendish, who discovered hydrogen by dissolving metals in acids, and then showed that when hydrogen is burned in oxygen, the resulting compound is pure water. Cavendish also combined the nitrogen in the atmosphere with oxygen by means of electrical sparks. The remaining bubble of atmospheric gas, which stubbornly refused to combine with oxygen, was later shown to be a new element - argon.

The great interest in gas chemistry shown by intelligent people of the period can be seen in Josiah Wedgwood's suggestions to the painter, George Stubbs, who was commissioned to make a portrait of Wedgwood's children:

"The two family pieces I have hinted at, I mean to contain the children only, and grouped perhaps in some such manner as this - Sukey playing upon her harpsichord with Kitty singing to her, as she often does, and Sally and Mary Ann upon the carpet in some

employment suitable to their ages. This to be one picture. The pendant to be Jack standing at a table making fixable air with the glass apparatus etc., and his two brothers accompanying him, Tom jumping up and clapping his hands in joy, and surprized at seeing the stream of bubbles rise up just as Jack has put a little chalk to the acid. Jos with the chemical dictionary before him in a thoughtful mood; which actions will be exactly descriptive of their respective characters."

The force of feudal traditions was still so strong, however, that in spite of Josiah Wedgwood's suggestions, George Stubbs painted the children on horseback, looking precisely like the children of a traditional landlord. The "fixable air" which Wedgwood mentions was the contemporary word for carbon dioxide. Josiah Wedgwood's daughter, Sukey (Susannah), was destined to become the mother of the greatest biologist of all time, Charles Darwin.

C.7 Adam Smith

One of Joseph Black's best friends at Glasgow University was the Professor of Moral Philosophy, Adam Smith. In 1759, Smith published a book entitled *The Theory of Moral Sentiments*, which was subtitled: *An Essay towards an Analysis of the Principles by which Men naturally judge concerning the Conduct and Character, first of their Neighbors, and afterwards of themselves.*

In this book, Adam Smith pointed out that people can easily judge the conduct of their neighbors. They certainly know when their neighbors are treating them well, or badly. Having learned to judge their neighbors, they can, by analogy, judge their own conduct. They can tell when they are mistreating their neighbor or being kind by asking themselves: "Would I want him to do this to me?" As Adam Smith put it:

"Our continual observations upon the conduct of others insensibly lead us to form to ourselves certain general rules concerning what is fit and proper to be done or avoided... It is thus the general rules of morality are formed."

When we are kind to our neighbors, they maintain friendly relations with us; and to secure the benefits of their friendship, we are anxious to behave well towards other people. Thus, according to Adam Smith, enlightened self-interest leads men and women to moral behaviour.

In 1776, Adam Smith published another equally optimistic book, with a similar theme: *The Wealth of Nations.* In this book, he examined the reasons why some nations are more prosperous than others. Adam Smith concluded that the two main factors in prosperity are division of labor and economic freedom.

As an example of the benefits of division of labor, he cited the example of a pin factory, where ten men, each a specialist in a particular manufacturing operation, could produce 48,000 pins per day. One man drew the wire, another straightened it, a third pointed the pins, a fourth put on the heads, and so on. If each man had worked separately, doing all the operations himself, the total output would be far less. The more complicated the manufacturing process (Smith maintained), the more it could be helped by division of labor. In the most complex civilizations, division of labor has the greatest utility.

Adam Smith believed that the second factor in economic prosperity is economic freedom, and in particular, freedom from mercantilist government regulations. He believed that natural economic forces tend to produce an optimum situation, in which each locality specializes in the economic operation for which it is best suited.

Smith believed that when each individual aims at his own personal prosperity, the result is the prosperity of the community. A baker does not consciously set out to serve society by baking bread - he only intends to make money for himself; but natural economic forces lead him to perform a public service, since if he were not doing something useful, people would not pay him for it. Adam Smith expressed this idea in the following way:

"As every individual, therefore, endeavours as much as he can, both to employ his capital in support of domestic industry, and so to direct that industry that its produce may be of greatest value, each individual necessarily labours to render the annual revenue of the Society as great as he can."

"He generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. By preferring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain; and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention. Nor is it always the worse for Society that it was no part of it. By pursuing his own interest, he frequently promotes that of society more effectively than when he really intends to promote it."

In Adam Smith's optimistic view, an "invisible hand" guides individuals to promote the public good, while they consciously seek only their own gain. This vision was enthusiastically adopted adopted by the vigorously growing industrial nations of the west. It is the basis of much of modern history; but there proved to be shortcomings in Smith's theory. A collection of individuals, almost entirely free from governmental regulation, each guided only by his or her desire for personal gain - this proved to be a formula for maximum economic growth; but certain modifications were needed before it could lead to widely shared happiness and social justice.

The dark, Satanic mills

Both Matthew Boulton and Josiah Wedgwood were model employers as well as pioneers of the factory system. Matthew Boulton had a pension scheme for his men, and he made every effort to insure that they worked under comfortable conditions. However, when he died in 1809, the firm of Boulton and Watt was taken over by his son, Matthew Robbinson Boulton, in partnership with James Watt Jr.. The two sons did not have their fathers' sense of social responsibility; and although they ran the firm very efficiently, they seemed to be more interested in profit-making than in the welfare of their workers.

A still worse employer was Richard Arkwright (1732-1792), who held patents on a series of machines for carding, drawing and spinning silk, cotton, flax and wool. He was a rough, uneducated man, who rose from humble origins to become a multimillionaire by driving

himself almost as hard as he drove his workers. Arkwright perfected machines (invented by others) which could make extremely cheap and strong cotton thread; and as a result, a huge cotton manufacturing industry grew up within the space of a few years. The growth of the cotton industry was especially rapid after Arkwright's patent expired in 1785.

Crowds of workers, thrown off the land by the Enclosure Acts, flocked to the towns, seeking work in the new factories. Wages fell to a near-starvation level, hours of work increased, and working conditions deteriorated. Dr. Peter Gaskell, writing in 1833, described the condition of the English mill workers as follows:

"The vast deterioration in personal form which has been brought about in the manufacturing population during the last thirty years... is singularly impressive, and fills the mind with contemplations of a very painful character... Their complexion is sallow and pallid, with a peculiar flatness of feature caused by the want of a proper quantity of adipose substance to cushion out the cheeks. Their stature is low - the average height of men being five feet, six inches... Great numbers of the girls and women walk lamely or awkwardly... Many of the men have but little beard, and that in patches of a few hairs... (They have) a spiritless and dejected air, a sprawling and wide action of the legs..."

"Rising at or before daybreak, between four and five o'clock the year round, they swallow a hasty meal or hurry to the mill without taking any food whatever... At twelve o'clock the engine stops, and an hour is given for dinner... Again they are closely immured from one o'clock till eight or nine, with the exception of twenty minutes, this being allowed for tea. During the whole of this long period, they are actively and unremittingly engaged in a crowded room at an elevated temperature."

Dr. Gaskell described the housing of the workers as follows:

"One of the circumstances in which they are especially defective is that of drainage and water-closets. Whole ranges of these houses are either totally undrained, or very partially... The whole of the washings and filth from these consequently are thrown into the front or back street, which, often being unpaved and cut into deep ruts, allows them to collect into stinking and stagnant pools; while fifty, or even more than that number, having only a single convenience common to them all, it is in a very short time choked with excrementous matter. No alternative is left to the inhabitants but adding this to the already defiled street."

"It frequently happens that one tenement is held by several families... The demoralizing effects of this utter absence of domestic privacy must be seen before they can be thoroughly appreciated. By laying bare all the wants and actions of the sexes, it strips them of outward regard for decency - modesty is annihilated - the father and the mother, the brother and the sister, the male and female lodger, do not scruple to commit acts in front of each other which even the savage keeps hid from his fellows."

"Most of these houses have cellers beneath them, occupied - if it is possible to find a lower class - by a still lower class than those living above them."

The abuse of child labor was one of the worst features of early industrialism in England. Sometimes small children, starting at the age of six or seven, were forced to work, because wages were so low that the family would otherwise starve; and sometimes the children were orphans, taken from parish workhouses. The following extract from John Fielden's book,

The Curse of the Factory System (1836), describes the condition of young children working in the cotton industry:

"It is well known that Arkwright's (so called at least) inventions took manufactures out of the cottages and farmhouses of England... and assembled them in the counties of Derbyshire, Nottinghamshire and more particularly, in Lancashire, where the newly-invented machinery was used in large factories built on the side of streams capable of turning the water wheel. Thousands of hands were suddenly required in these places, remote from towns."

"The small and nimble fingers of children being by far the most in request, the custom instantly sprang up of procuring 'apprentices' from the different parish workhouses of London, Birmingham and elsewhere... Overseers were appointed to see to the works, whose interest it was to work the children to the utmost, because their pay was in proportion to the quantity of work which they could exact."

"Cruelty was, of course, the consequence; and there is abundant evidence on record to show that in many of the manufacturing districts, the most heart-rending cruelties were practiced on the unoffending and friendless creatures... that they were flogged, fettered and tortured in the most exquisite refinement of cruelty, that they were, in many cases, starved to the bone while flogged to their work, and that even in some instances they were driven to commit suicide... The profits of manufacture were enormous; but this only whetted the appetite it should have satisfied."

One of the arguments which was used to justify the abuse of labor was that the alternative was starvation. The population of Europe had begun to grow rapidly for a variety of reasons: - because of the application of scientific knowledge to the prevention of disease; because the potato had been introduced into the diet of the poor; and because bubonic plague had become less frequent after the black rat had been replaced by the brown rat, accidentally imported from Asia.

It was argued that the excess population could not be supported unless workers were employed in the mills and factories to produce manufactured goods, which could be exchanged for imported food. In order for the manufactured goods to be competitive, the labor which produced them had to be cheap: hence the abuses. (At least, this is what was argued).

Overpopulation

When the facts about the abuse of industrial workers in England became known, there were various attempts to explain what had gone wrong with the optimistic expectations of the Enlightenment. Among the writers who discussed this problem was the economist David Ricardo (1772-1823). In his book, *The Principles of Political Economy and Taxation* (1817), Ricardo proposed his "iron law of wages".

According to Ricardo, labor is a commodity, and wages are determined by the law of supply and demand: When wages fall below the starvation level, the workers' children die. Labor then becomes a scarce commodity, and the wages rise. On the other hand, when

wages rise above the starvation level, the working population multiplies rapidly, labor becomes a plentiful commodity, and wages fall again. Thus, according to Ricardo, there is an "iron law" which holds wages at the minimum level at which life can be supported.

Ricardo's reasoning assumes industrialists to be completely without social conscience or governmental regulation; it fails to anticipate the development of trade unionism; and it assumes that the working population will multiply without restraint as soon as their wages rise above the starvation level. This was an accurate description of what was happening in England during Ricardo's lifetime, but it obviously does not hold for all times and all places.

A more general and complete description of the situation was given by Thomas Robert Malthus (1766-1834). Malthus came from an intellectual family: His father, Daniel Malthus, was a friend of Rousseau, Hume and Goodwin. The famous book on population by the younger Malthus grew out of his conversations with his father.

Daniel Malthus was an enthusiastic believer in the optimistic philosophy of the Enlightenment. Like Goodwin, Condorcet and Voltaire, he believed that the application of scientific progress to agriculture and industry would inevitably lead humanity forward to a golden age. His son, Robert, was more pessimistic. He pointed out that the benefits of scientific progress would probably be eaten up by a growing population.

At his father's urging, Robert Malthus developed his ideas into a book, *An Essay on the Principle of Population*, which he published anonymously in 1798. In this famous book, Malthus pointed out that under optimum conditions, every biological population, including that of humans, is capable of increasing exponentially. For humans under optimum conditions, the population can double every twenty-five years, quadruple every fifty years and increase by a factor of 8 every seventy-five years. It can grow by a factor of 16 every century, and by a factor of 256 every two centuries, and so on.

Obviously, human populations cannot increase at this rate for very long, since if they did, the earth would be completely choked with people in a very few centuries. Therefore, Malthus pointed out, various forces must be operating to hold the population in check. Malthus listed first the "positive checks" to population growth - disease, famine and war - which we now call the "Malthusian forces". In addition, he listed checks of another kind - birth control (which he called "Vice"), late marriage, and "Moral Restraint". Being a clergyman, Malthus naturally favored moral restraint.

According to Malthus, a population need not outrun its food supply, provided that late marriage, birth control or moral restraint are practiced; but without these less painful checks, the population will quickly grow to the point where the grim Malthusian forces - famine, disease and war - begin to act.

Curiously, it was France, a Catholic country, which led the way in the development of birth control. Robert Owen (who was an enlightened English industrialist, and the founder of the cooperative movement), wished to advise his workers about birth control; and so he went to France to learn about the techniques practiced there. In 1825, an article (by Richard Carlile) appeared in *The Republican*. The article described the importation of birth control from France to England as follows:

"...It was suggested to Mr. Owen that, in his new establishments, the healthy state of

the inhabitants would tend to breed an excess of children. The matter was illustrated and explained to him, so that he felt the force of it. He was told that on the Continent, the women used some means of preventing conception which were uniformly successful. Mr. Owen set out for Paris to discover the process. He consulted the most eminent physicians, and assured himself of what was the common practice among their women."

"...A piece of soft sponge is tied by a bobbin or penny ribbon, and inserted before sexual intercourse takes place, and is withdrawn again as soon as it has taken place... If the sponge be large enough, that is, as large as a green walnut or a small apple, it will prevent conception, without diminishing the pleasures of married life."

Carlile goes on to say:

"...When the number of working people in any trade or manufacture has for some years been too great, wages are reduced very low, and the working people become little better than slaves... By limiting the number of children, the wages of both children and grown persons will rise; and the hours of working will be no more than they ought to be."

Birth control and late marriage have (until now) kept the grim predictions of Ricardo and Malthus from being fulfilled in the developed industrial nations of the modern world. Most of these nations have gone through a process known as the "demographic transition" - the shift from an equilibrium where population growth is held in check by the Malthusian forces of disease, starvation and war, to one where it is held in check by birth control and late marriage.

The transition begins with a fall in the death rate, caused by various factors, among which the most important is the application of scientific knowledge to the prevention of disease. Cultural patterns require some time to adjust to the lowered death rate, and so the birth rate continues to be high. Families continue to have six or seven children, just as they did when most of the children died before having children of their own. Therefore, at the start of the demographic transition, the population increases sharply. After a certain amount of time, however, cultural patterns usually adjust to the lowered death rate, and a new equilibrium is established, where both the birth rate and the death rate are low.

In Europe, this period of adjustment required about two hundred years. In 1750, the death rate began to fall sharply: By 1800, it had been cut in half, from 35 deaths per thousand people in 1750 to 18 in 1800; and it continued to fall. Meanwhile, the birth rate did not fall, but even increased to 40 births per thousand per year in 1800. Thus the number of children born every year was more than twice the number needed to compensate for the deaths!

By 1800, the population was increasing by more than two percent every year. In 1750, the population of Europe was 150 million; by 1800, it was roughly 220 million; by 1950 it had exceeded 540 million, and in 1970 it was 646 million.

Meanwhile the achievements of medical science and the reduction of the effects of famine and warfare had been affecting the rest of the world: In 1750, the non-European population of the world was only 585 million. By 1850 it had reached 877 million. During the century between 1850 and 1950, the population of Asia, Africa and Latin America more than doubled, reaching 1.8 billion in 1950. In the twenty years between 1950 and 1970, the population of Asia, Africa and Latin America increased still more sharply, and in

1970, this segment of the world's population reached 2.6 billion, bringing the world total to 3.6 billion. The fastest increase was in Latin America, where population almost doubled during the twenty years between 1950 and 1970.

The latest figures show that the population explosion is leveling off in Europe, Russia, North America and Japan, where the demographic transition is almost complete. However, the population of the rest of the world is still increasing at a breakneck speed; and it cannot continue to expand at this rate for very much longer without producing widespread famine.

C.8 Colonialism

In the 18th and 19th centuries, the continually accelerating development of science and science-based industry began to affect the whole world. As the factories of Europe poured out cheap manufactured goods, a change took place in the patterns of world trade: Before the Industrial Revolution, trade routes to Asia had brought Asian spices, textiles and luxury goods to Europe. For example, cotton cloth and fine textiles, woven in India, were imported to England. With the invention of spinning and weaving machines, the trade was reversed. Cheap cotton cloth, manufactured in England, began to be sold in India, and the Indian textile industry withered.

The rapid development of technology in the west also opened an enormous gap in military strength between the industrialized nations and the rest of the world. Taking advantage of their superior weaponry, the advanced industrial nations rapidly carved the remainder of the world into colonies, which acted as sources of raw materials and food, and as markets for manufactured goods.

In North America, the native Indian population had proved vulnerable to European diseases, such as smallpox, and large numbers of them had died. The remaining Indians were driven westward by streams of immigrants arriving from Europe. In Central and South America, European diseases proved equally fatal to the Indians.

Often the industrialized nations made their will felt by means of naval bombardments: In 1854, Commodore Perry and an American fleet forced Japan to accept foreign traders by threatening to bombard Tokyo. In 1856, British warships bombarded Canton in China to punish acts of violence against Europeans living in the city. In 1864, a force of European and American warships bombarded Choshu in Japan, causing a revolution. In 1882, Alexandria was bombarded, and in 1896, Zanzibar.

Between 1800 and 1875, the percentage of the earth's surface under European rule increased from 35 percent to 67 percent. In the period between 1875 and 1914, there was a new wave of colonial expansion, and the fraction of the earth's surface under the domination of colonial powers (Europe, the United States and Japan) increased to 85 percent, if former colonies are included.

During the period between 1880 and 1914, English industrial and colonial dominance began to be challenged. Industrialism had spread from England to Belgium, Germany and the United States, and, to a lesser extent, to France, Italy, Russia and Japan. By 1914, Germany was producing twice as much steel as Britain, and the United States was

producing four times as much.

New techniques in weaponry were introduced, and a naval armaments race began among the major industrial powers. The English found that their old navy was obsolete, and they had to rebuild. Thus, the period of colonial expansion between 1880 and 1914 was filled with tensions, as the industrial powers raced to arm themselves in competition with each other, and raced to seize as much as possible of the rest of the world.

Much that was beautiful and valuable was lost, as mature traditional cultures collapsed, overcome by the power and temptations of modern industrial civilization. For the Europeans and Americans of the late 19th century and early 20th century, progress was a religion, and imperialism was its crusade. The cruelties of the crusade were justified, in the eyes of the westerners, by their mission to "civilize" and Christianize the rest of the world. To a certain extent, the industrial countries were right in feeling that they had something of value to offer to the rest of the world; and among the people whom they sent out were educators and medical workers who often accepted lives of extreme discomfort and danger in order to be of service.

At the beginning of the 19th century, the world was divided into parts: China was a world in itself; India was a separate world; Africa south of the Sahara was another enclosed world; and the Islamic world was also self-contained, as was the west. By 1900, there was only one world, bound together by constantly-growing ties of trade and communication.

C.9 Trade Unions and minimum wage laws

Robert Owen and social reform

During the early phases of the Industrial Revolution in England, the workers suffered greatly. Enormous fortunes were made by mill and mine owners, while workers, including young children, were paid starvation wages for cruelly long working days. However, trade unions, child labor laws, and the gradual acceptance of birth control finally produced a more even distribution of the benefits of industrialization.

One of the most interesting pioneers of these social reforms was Robert Owen (1771-1858), who is generally considered to have been the father of the Cooperative Movement. Although in his later years not all of his projects developed as he wished, his life started as an amazing success story. Owen's life is not only fascinating in itself; it also illustrates some of the reforms that occurred between 1815 and 1850.

Robert Owen was born in Wales, the youngest son of a family of iron-mongers and saddle-makers. He was a very intelligent boy, and did well at school, but at the age of 9, he was apprenticed to a draper, at first in Wales. Later, at the age of 11, he was moved to London, where he was obliged to work eighteen hours a day, six days a week, with only short pauses for meals. Understandably, Robert Owen found this intolerable, and he moved again, this time to Manchester, where he again worked for a draper.

While in Manchester, Robert Owen became interested in the machines that were beginning to be used for spinning and weaving. He borrowed a hundred pounds from his brother,

and entered (as a partner) a small business that made these machines. After two years of moderate success as a small-scale industrialist, Owen saw the newspaper advertisement of a position for manager of a large spinning mill, owned by a Mr. Drinkwater.

"I put on my hat", Owen wrote later, "and proceeded straight to Mr. Drinkwater's counting house. 'How old are you?' 'Twenty this May', was my reply. 'How often do you get drunk in the week?'... 'I was never', I said, 'drunk in my life.' blushing scarlet at this unexpected question. 'What salary do you ask?' 'Three hundred a year', was my reply. 'What?', Mr. Drinkwater said with some surprise, repeating the words, 'Three hundred pounds! I have had this morning I know not how many seeking the situation and I do not think that all of their askings would amount to what you require.' 'I cannot be governed by what others seek', said I, 'and I cannot take less.'

Apparently impressed by Robert Owen's success as a small-scale industrialist, and perhaps also impressed by his courage, Mr. Drinkwater hired him. Thus, at the age of 19, Owen became the manager of a large factory. Mr. Drinkwater had no cause to regret his decision, since his new manager quickly became the boy wonder of Manchester's textile community. Within six months, Drinkwater offered Owen a quarter interest in his business.

After several highly successful years in his new job, Robert Owen heard of several mills that were for sale in the village of New Lanark, near to Glasgow. The owner, Mr. Dale, happened to be the father of the girl with whom Robert Owen had fallen in love. Instead of directly asking Dale for permission to marry his daughter, Owen (together with some business partners) first purchased the mills, after which he won the hand of the daughter.

Ownership of the New Lanark mills gave Robert Owen the chance to put into practice the ideas of social reform that he had been developing throughout his life. Instead of driving his workers by threats of punishment, and instead of subjecting them to cruelly long working hours (such as he himself had experienced as a draper's apprentice in London), Owen made the life of his workers at New Lanark as pleasant as he possibly could. He established a creche for the infants of working mothers, free medical care, concerts, dancing, music-making, and comprehensive education, including evening classes. Instead of the usual squalid one-room houses for workers, neat two-room houses were built. Garbage was collected regularly instead of being thrown into the street. New Lanark also featured pleasant landscaped areas.

Instead of leading to bankruptcy, as many of his friends predicted, Robert Owen's reforms led to economic success. Owen's belief that a better environment would lead to better work was vindicated. The village, with its model houses, schools and mills, became internationally famous as a demonstration that industrialism need not involve oppression of the workers. Crowds of visitors made the journey over narrow roads from Glasgow to learn from New Lanark and its visionary proprietor. Among the twenty thousand visitors who signed the guest-book between 1815 and 1825 were the Grand Duke Nicholas of Russia (who later became Czar Nicholas I), and Princes John and Maximilian of Austria.

Robert Owen's ideas of social reform can be seen in the following extract from an "Address to the Inhabitants of New Lanark", which he presented on New Year's Day, 1616: "What ideas individuals may attach to the term 'Millennium' I know not; but I know that society may be formed so as to exist without crime, without poverty, with

Figure C.10: **New Lanark World Heritage village in Scotland. A view of the school.**

health greatly improved, with little, if any, misery. and with intelligence and happiness increased a hundredfold; and no obstacle whatsoever intervenes at this moment except ignorance to prevent such a state of society from becoming universal."

Robert Owen believed that these principles could be applied not only in New Lanark but also in the wider world. He was soon given a chance to express this belief. During the years from 1816 to 1820, apart from a single year, business conditions in England were very bad, perhaps as a result of the Napoleonic Wars, which had just ended. Pauperism and social unrest were widespread, and threatened to erupt into violence. A committee to deal with the crisis was formed under the leadership of the Dukes of Kent and York.

Because of Owen's reputation, he was asked for his opinion, but the committee was hardly expecting the answer that they received from him. Robert Owen handed the two Dukes and the other committee members a detailed plan for getting rid of pauperism by making paupers productive. They were to be settled in self-governing Villages of Cooperation, each with between 800 and 1,200 inhabitants. Each family was to have a private apartment, but there were to be common sitting rooms, reading rooms and kitchens. Near to the houses, there were to be gardens tended by the children, and farther out, fields to be cultivated by the adults. Still farther from the houses, there was to be a small factory.

Owen's idea for governmentally-planned paupers' collectives was at first rejected out of hand. The early 19th century was, after all, a period of unbridled *laissez-faire* economics. Owen then bombarded the Parliament with pamphlets advocating his scheme. Finally a committee was formed to try to raise the money to establish one Village of Cooperation as an experiment; but the money was never raised.

Unwilling to accept defeat, Robert Owen sold his interest in New Lanark and sailed for America, where he believed that his social experiment would have a better chance of success. He bought the town of Harmonie and 30,000 acres of land on the banks of the Wabash River in Indiana. There he established a Village of Cooperation which he named "New Harmony". He dedicated it on the 4th of July, 1826. It remained a collective for only two years, after which individualism reasserted itself. Owen's four sons and one of his daughters made their homes in New Harmony, and it also became the home of numerous scientists, writers and artists.

Owen's son, Robert Dale Owen, became a member of the U.S. House of Representatives, where he introduced the bill establishing the Smithsonian Institution. In 1862 he wrote an eloquent letter to Abraham Lincoln urging emancipation of the slaves. Three days later, probably influenced by Owen's letter, Lincoln read the Emancipation Proclamation to his cabinet. Another son, Richard Owen, served as President of the University of Indiana, and was later elected as the first President of Purdue University.

When Robert Owen returned to England shortly after dedicating New Harmony, he found that he had become a hero of the working classes. They had read his writings avidly, and had begun to establish cooperatives, following his principles. There were both producer's cooperatives and consumer's cooperatives. In England, the producer's cooperatives failed, but in Denmark they succeeded[2].

One of the early consumer's cooperatives in England was called the Rochdale Society of Equitable Pioneers. It was founded by 28 weavers and other artisans, who were being forced into poverty by mechanization. They opened a small cooperative store selling butter, sugar, flour, oatmeal and candles. After a few months, they also included tobacco and tea. From this small beginning, the Cooperative Movement grew, finally becoming one of the main pillars of the British Labour Party.

Robert Owen's attention now turned from cooperatives to the embryonic trade union movement, which was struggling to establish itself in the face of fierce governmental opposition. He assembled the leaders of the working class movement and proposed the formation of the "Grand National Moral Union of Productive and Useful Classes". The name was soon shortened to "The Grand National Consolidated Trades Union" or simply the "Grand National".

Owen's Grand National was launched in 1833, and its membership quickly grew to half a million. It was the forerunner of modern nationwide trade unions, but it lasted only two years. Factory-owners saw the Grand National as a threat, and they persuaded the government to prosecute it under anti-union laws. Meanwhile, internal conflicts helped to destroy the Grand National. Owen was accused of atheism by the working class leaders, and he accused them of fermenting class hatred.

Robert Owen's influence helped to give raw *laissez faire* capitalism a more human face, and helped to spread the benefits of industrialization more widely. Through the work of other reformers like Owen, local trade unions succeeded, both in England and elsewhere;

[2]The success of Danish agricultural producer's cooperatives was helped by the People's High School movement, founded by N.F.S. Grundvig (1783-1872).

Figure C.11: **Robert Owen, (1771-1858), founder of the Cooperative Movement.**

and in the end, successful national unions were finally established. The worst features of the early Industrial Revolution were moderated by the growth of the trade union movement, by child labor laws, by birth control and by minimum wage laws.

Rusting of the Iron Law

David Ricardo's Iron Law of Wages maintained that workers must necessarily live at the starvation level: Their wages are determined by the law of supply and demand, Ricardo said. If the wages should increase above the starvation level, more workers' children would survive, the supply of workers would increase, and the wages would fall again. This gloomy pronouncement was enthusiastically endorsed by members of the early 19th century Establishment, since it absolved them from responsibility for the miseries of the poor. However, the passage of time demonstrated that the Iron Law of Wages held only under the assumption of an economy totally free from governmental intervention.

Both the growth of the political power of industrial workers, and the gradual acceptance of birth control were important in eroding Ricardo's Iron Law. Birth control is especially important in countering the argument used to justify child labor under harsh conditions. The argument (still used in many parts of the world) is that child labor is necessary in order to save the children from starvation, while the harsh conditions are needed because if a business provided working conditions better than its competitors, it would go out of business. However, with a stable population and appropriate social legislation prohibiting both child labor and harsh working conditions, the Iron Law argument fails.

C.10 Rising standards of living

Since the year 1000, world population has risen 22-fold, global per capita Gross Domestic Product 13-fold, and world GDP nearly 300-fold. These data come from Angus Maddison's recent book, *World Population, GDP and Per Capita GDP, 1-2003*. More detailed data, from a report that Prof. Maddison presented to the British House of Lords, are shown in Tables 5.1 and 5.2.

During the period between 1820 and 2001, the average years of education per person employed increased from 2.00 years to 15.45 years in the United Kingdom, from 1.75 years to 20.21 years in the United States, and from 1.50 years to 16.61 years in Japan. This increased education in the highly industrialized countries was necessary because of the complexity of modern machines and modern life.

Today, most citizens of the industrialized countries have lives of greatly-increased pleasure and freedom compared with the lives of their great-grandparents. Furthermore, their lives are also remarkably easy and pleasant compared with the remainder of the world. In later chapters we will try to discuss to what extent this privileged life-style is sustainable.

Table C.1: GDP per capita (1990 int. $). Data from Maddison.

	1900	1950	1990	2001
W. Europe	2,893	4,579	15,966	19,256
USA	4,091	9,561	23,201	27,948
Ca.,Au.,NZ	3,435	7,424	17,902	21,718
Japan	1,180	1,921	18,789	20,683
E. Europe	1,438	2,111	5,450	6,207
fUSSR	1,237	2,841	6,878	4,626
L. America	1,109	2,506	5,053	5,811
China	545	439	1,858	3,583
India	599	619	1,309	1,957
Other Asia	802	919	3,084	3,997
Africa	601	894	1,444	1,489
World	1,262	2,111	5,157	6,049

Table C.2: Gross stock of machinery and equipment per capita (1990 $). Data from Maddison. These figures are a measure of the degree of industrialization of the countries shown. Similar increases occurred in the gross stock of non-residential structures per capita. For example, in the USA the value of these structures increased from $1,094 (1990 $) in 1820 to $36,330 in 2001. In Japan there was a dramatic increase during the 20th century, from $852 per capita in 1913 to $57,415 in 2001.

	UK	USA	Japan
1820	92	87	na
1870	334	489	94
1913	878	2,749	329
1950	2,122	6,110	1,381
1973	6,203	10,762	6,431
2001	16,082	30,600	32,929

C.11 Robber barons and philanthropists

"Hain't I got the power?"

We can experience some of the flavor of early American industrial growth by looking at the life of Cornelius Vanderbilt (1794-1877). In those days, the United States was a place where a man with luck, intelligence and energy, could start with nothing and become a multimillionaire. That is exactly what Vanderbilt did.

Vanderbilt was born into a poor New York family. He quit school at 11 to help his father, and later remarked, "If I had learned education, I wouldn't have had time to learn anything else." At 16 he started his first business, using $100 borrowed from his mother - a small ferry boat between New York and Staten Island, charging 18 cents per trip. The business succeeded because of the fair price that he charged and because of his prodigious work. Within a year, he was able to give his mother $1,000 in return for her loan.

During the War of 1812, Vanderbilt had a government contract to sail supplies to forts in the New York area. He was by then operating a small fleet of sailing schooners, and as a consequence he received the nickname, "Commodore".

Cornelius Vanderbilt then became interested in steamships, but Robert Fulton and Robert Livingston had been granted a 30-year monopoly on the steamboat trade. This did not stop Vanderbilt. He started a competing steam line, and his boat evaded capture. Finally a Supreme Court decision broke the Fulton-Livingston monopoly. By the 1840's, Vanderbilt was operating about 100 steamships, and his business had the most employees of any in the United States.

Turning his attention to railways, Vanderbilt bought several lines, including the New York and Harlem Railroad, the Hudson River Railroad, and the New York Central Railroad. He extended his lines as far as Chicago, and attempted to acquire the Erie Railroad. This brought him into conflict with the unscrupulous financier Jim Fisk. Vanderbilt's methods were equally rough, so it was a fight with no holds barred. (Cornelius Vanderbilt once remarked, "What do I care about the law? Hain't I got the power?")

At the time of his death, Cornelius Vanderbilt was one of the richest men in the United States, with a fortune of over $100,000,000. He left most of this amount to his son William [3], but gave one million to Central University, which then became Vanderbilt University.

Carnegie's philanthropies

We can contrast Vanderbilt's relatively small interest in philanthropy with Andrew Carnegie's large-scale efforts for public improvement. Like Vanderbilt, Andrew Carnegie (1835-1919) was a self-made multimillionaire, but after making a fortune in oil wells, steel, iron ore and railways, he gave almost all of his money away. Early in his career, he wrote:

"I propose to take an income no greater than $50,000 per annum! Beyond this I need never earn, make no effort to increase my fortune, but spend the surplus each year for benevolent purposes! Let us cast aside business forever, except for others. Let us settle in

[3] William Vanderbilt is best remembered for his remark, "The public be damned!"

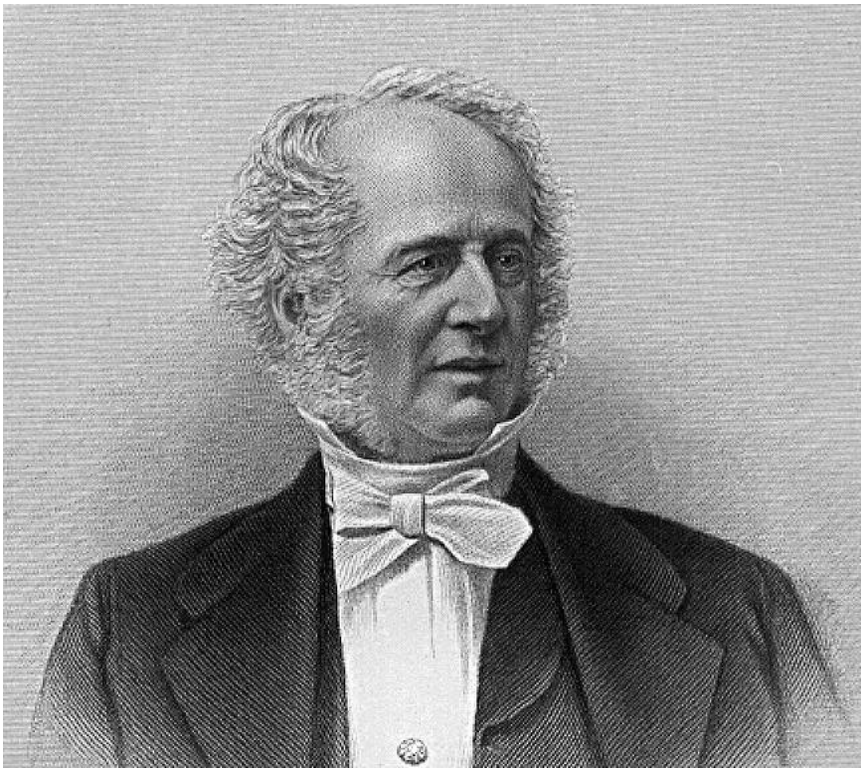

Figure C.12: **Cornelius "Commodore" Vanderbilt.**

Figure C.13: **Andrew Carnegie circa 1878.**

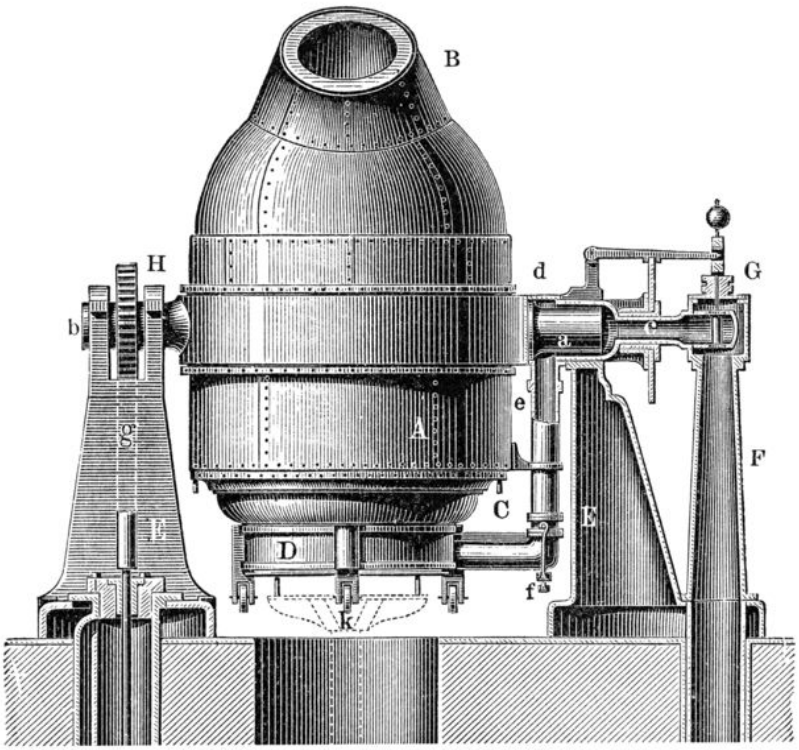

Figure C.14: **A Bessemer converter, used in making steel.**

Oxford, and I shall get a thorough education, making the acquaintance of literary men... To continue much longer overwhelmed by business cares and with most of my thoughts wholly upon the way to make more money in the shortest time, must degrade me beyond hope of permanent recovery."

When he sold his share of the United States Steel Corporation in 1901, Andrew Carnegie became one of the wealthiest men in the world. He devoted the remainder of his life to educational projects and to philanthropy. He established a large number of public libraries, not only in the United Kingdom and in the United States, but also in Canada, Ireland, Australia, New Zealand, the West Indies and Fiji. In all, Carnegie established 3,000 libraries. In addition, he founded the Carnegie Institution in Washington D.C. and the Carnegie Institute of Technology in Pittsburgh, which later became the Carnegie Mellon University.

In Scotland, his birthplace, where he lived for part of each year, Andrew Carnegie established a trust to assist in university education. In recognition of this generous gift (and perhaps also in recognition of his authorship of a number of books and articles), Andrew Carnegie was elected Lord Rector of the University of St. Andrews. Carnegie also gave a large amount of money to Booker T. Washington's Tuskegee Institute. He established generous pension funds for his former employees, and also for American university professors. As if all this were not enough, he paid for the construction of 7,000 church organs,

contributed to the erection of the Peace Palace at the Hague, and established the Carnegie Foundation, which continues to perform good works, especially in the field of education.

In the lives of Cornelius Vanderbilt and Andrew Carnegie we see exemplified some of the features of the age in which they lived, when ruthless business behavior was often balanced by splendid acts of public generosity.

C.12 The conflict between capitalism and communism

The Russian Revolution

Industrialism in Russia started more slowly than in Europe and the United States. The emancipation of the surfs in 1861 by Czar Alexander II was incompletely carried out in practice, and Russia remained, to a large extent, in the grip of feudal absolutism. Dissatisfaction with the slowness of reform led to a series of protests. On January 22, 1905 (Bloody Sunday), a group of marchers in St. Petersburg brought a petition to the Winter Palace, hoping to hand it to the Czar. The petition called for improvement of working conditions, democratic elections, and establishment of a constituent assembly. Without the Tzar's knowledge (he was not in St. Petersburg at the time), government troops fired on the marchers, and about 1,000 were killed.

Between 1905 and 1908, strikes and peasant disorders occurred throughout Russia. The revolt of sailors on the Battleship Potemkin, upon which Sergei Eisenstein based his famous film, also occurred at this time.

In 1914, Russia entered the First World War on the side of England and France. The Russian troops were badly supplied, and suffered heavy casualties. With the soldiers absent from their fields, some of the larger Russian cities were threatened with famine.

By February, 1917, dissatisfaction had reached such a level that a total general strike occurred in St Petersburg. Instead of putting down this strike, weary Russian soldiers supported it, handing over their weapons to members of the angry crowds. These events lead to the abdication of Czar Nicholas II, who handed over power to the Kerensky Provisional Government. In October, 1917, the Bolsheviks under the leadership of V.I. Lenin, gained power. Lenin had been exile in Switzerland before returning to lead the October Revolution, and he was a follower of the communist economist, Karl Marx.

The First Red Scare; McCarthyism; the Cold War

There were two distinct periods of violent anti-communism in the United States. The "First Red Scare" occurred between 1917 and 1920, while "McCarthyism" began in the late 1940's and lasted until the late 1950's.

The "First Red Scare" was largely inspired by the fear that the 1917 revolution in Russia would spread to the United States. In 1919, a bomb plot was uncovered; bombs were to be sent through the post to 36 prominent Americans, including John Pierpont Morgan, John D. Rockefeller and Supreme Court Justice Oliver Wendell Holmes. The year 1919 was also

characterized by hundreds of strikes throughout the United States. Newspapers described the strikes as communist plots, and the FBI arrested several thousand suspected agitators.

The McCarthy era occurred after World War II. The United States emerged from the war as the only major industrial power whose infrastructure had not been destroyed by the war. Thus the US found itself thrust somewhat reluctantly and nervously into a position of global leadership. Meanwhile a communist revolution had occurred in China, and this added to US nervousness, as did the Soviet development of nuclear weapons.

Senator Joseph McCarthy (1908-1957), and the House Un-American Activities Committee lead an aggressive populistic hunt for communists and "communist sympathizers". About 500 Hollywood actors, actresses and screenwriters were blacklisted.

The end of World War II also marked the start of the "Cold War" between capitalist and communist countries. The most dangerous feature of the Cold War was a nuclear arms race that resulted in a truly insane number of nuclear weapons. At the height of this arms race there were over 50,000 nuclear weapons in the world, with a total explosive power roughly a million times greater than the bomb that destroyed Hiroshima in 1945. Put another way, the bombs had an explosive power equivalent to 4 tons of TNT for every person on the planet. The world came close to thermonuclear war on several occasions, for example during the Cuban Missile Crisis of October, 1962. Although the Cold War has now ended, about 27,000 nuclear weapons still exist, many of them on hair-trigger alert. Because of the dangers of accidental nuclear war, nuclear proliferation and nuclear terrorism, these weapons continue to cast a very dark shadow over the future of humankind.

Capitalism triumphant

After the fall of the Berlin Wall in 1989, and the dissolution of the Soviet Union in 1991, capitalism spread to much of what had been the communist block of nations. Even China, although remaining officially a communist state, adopted capitalist methods on an experimental basis. Adam Smith, the prophet of the free market and of economic growth, was triumphant. We should notice that despite their differences regarding ownership of the means of production, capitalists and communists are united in their admiration of economic growth.

C.13 Globalization

In Chapter 3, we mentioned the exploitation of factory workers during the early phases of the Industrial Revolution. In the present chapter, we discussed how the growth of trade unions, the enactment of minimum wage laws, and laws preventing child labor, together with the gradual acceptance of birth control, led to a more widely-distributed prosperity, where workers shared the benefits of industrialization.

Today, economic globalization aims at increased trade throughout the world. At first sight, this seems to be a benefit. However, laws preventing the exploitation of labor are not universal. Workers in the developed countries can find themselves competing with grossly

underpaid labor in developing nations. The cure, of course, is to demand universal laws protecting workers from exploitation. Such laws must be a precondition for free trade.

C.14 Say's Law

Suburbia

The private automobile is the flagship of industrialism. In 2002, there were more than half a billion automobiles in the world. Of these, 140 million were in the United States (roughly one for every two people).

Reliance on private automobiles for transportation has affected the geography of cities, producing vast highway systems, urban sprawl and suburban life. For example, the Los Angeles metropolitan area spreads over 4,850 square miles (12,400 km^2). Because of the availability of inexpensive motor fuel, public transportation is almost non-existent in Los Angeles. It is not uncommon for a citizen of the city to drive several hundred kilometers during a normal day. Many other cities in the world have a similar dependence on private automobiles.

A recent Canadian documentary film, *The End of Suburbia*, explores the history and probable future of cities built around the availability of inexpensive gasoline. The subtitle of the film is *Oil Depletion and the Collapse of the American Dream.*

Keeping up appearances

Of course, if we live in suburbia, we have to keep up with the neighbors. This is hard to do, because the neighbors keep getting new things - bigger automobiles, motorboats, swimming pools, and so on. Not only must we keep up with our actual neighbors, we must also compete with the glamorous lives that we see in films and television.

According to Say's Law, and according to advertisers and economists, human desires have no upper limit; there is no limit to growth. Television advertising and billboards constantly tell us that to be happy, or even respectable, we need to buy more. Thus mainstream industrial culture thunders ahead, worshiping power, material goods, wealth, growth and progress. There is, however, a counterculture, which we will look at in the next chapter.

C.15 Veblen; economics as anthropology

The phrase "conspicuous consumption" was invented by the Norwegian-American economist Thorstein Veblen (1857-1929) in order to describe the way in which our society uses economic waste as a symbol of social status. In *The Theory of the Leisure Class*, first published in 1899, Veblen pointed out that it is wrong to believe that human economic behavior is rational, or that it can be understood in terms of classical economic theory. To

understand it, Veblen maintained, one might preferably make use of insights gained from anthropology, psychology, sociology, and history.

Thorstein Veblen was born into a large Norwegian immigrant family living on a farm in Wisconsin. His first language was Norwegian, and in fact he did not learn English well until he was in his teens. He was a strange boy, precociously addicted to reading, but negligent about doing his chores on the farm. His family recognized that he was unusually intelligent and decided to send him to Carlton College, where he obtained a B.A. in 1880. Later he did graduate work at Johns Hopkins University and finally obtained a Ph.D. from Yale in 1884.

Despite the Ph.D., he failed to obtain an academic position. His iconoclastic views and non-conformist attitudes undoubtedly contributed to this joblessness. Returning to the family farm, Thorstein Veblen continued his voracious reading and his neglect of farm duties for six years. As one of his brothers wrote, "He was lucky enough to come out of a race and family who made family loyalty a religion... He was the only loafer in a highly respectable community... He read and loafed, and the next day he loafed and read."

An interesting fact about this strange man is that, for some reason, women found him very attractive. In 1888, Thorstein Veblen married Ellen Rolfe, the niece of the president of Carlton College. His wife was to leave him many times, partly because of his many infidelities, and partly because of his aloofness and detachment. He was like a visitor from another planet.

In part, the marriage to Ellen was motivated by Veblen's search for a job. He hoped to obtain work as an economist for the Atchison, Topeka and Santa Fe Railway, of which her uncle was president. However, the railway was in financial difficulties, and it was taken over by bankers, after which the position disappeared.

Finally a family council was held on the Veblen farm, and it was decided that Thorstein should once again attempt to enter the academic world. In 1891, wearing corduroy trousers and a coonskin hat, he walked into the office of the conservative economist J.L. Laughlan and introduced himself. Although taken aback by Veblen's appearance, Laughlan began to talk with him, and he soon recognized Veblen's genius. A year later, when he moved to the University of Chicago, Laughlan brought Veblen with him at a salary of $520 per year.

At the University of Chicago, Veblen soon established a reputation both for eccentricity and for enormous erudition. His socks were held up by safety pins, but he was reputed to be fluent in twenty-six languages. He gained attention also by publishing a series of brilliant essays.

In 1899, Veblen "fluttered the dovecotes of the East" by publishing a book entitled *The Theory of the Leisure Class*. It was part economics, part anthropology, and part social satire. Nothing of the kind had ever been seen in the field of economics. Until that moment it had been universally assumed that human economic behavior is rational. Veblen's detached and surgically sharp intelligence exposed it as being very largely irrational.

According to Thorstein Veblen, ancient tribal instincts and attitudes motivate us today, just as they motivated our primitive ancestors. Veblen speaks of a predatory phase of primitive society where the strongest fighters were able to subjugate others. This primitive class structure was based on violence, and, according to Veblen, the attitudes associated

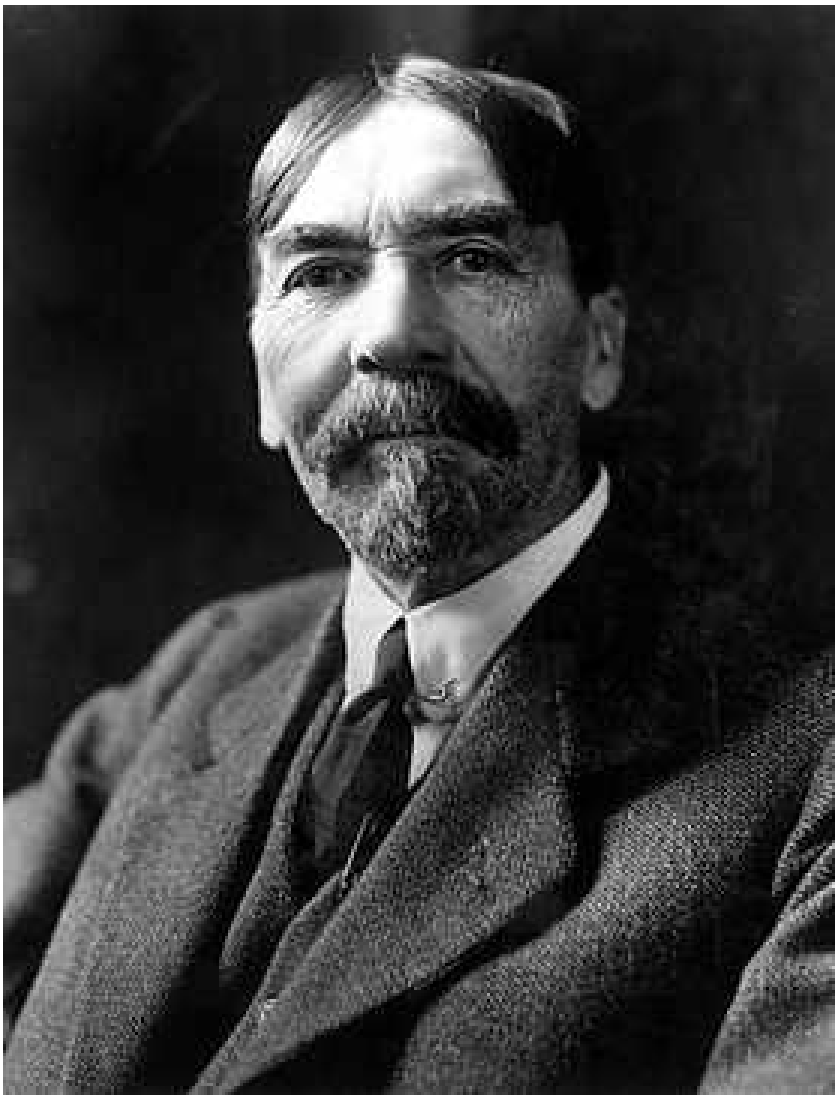

Figure C.15: **Thorstein Veblen (1857-1929).**

with it persist today.

For example, Veblen noted that male members of the leisure class liked to go about with walking sticks. Why? Because, answers Veblen, it is "an advertisement that the bearer's hands are employed otherwise than in useful effort." Also, a walking stick is a weapon: "The handling of so tangible and primitive a means of offense is very comforting to anyone who is gifted with even a moderate share of ferocity".

Even in modern society, Veblen says, we have an admiration for those who succeed in obtaining power and money through predatory means, and this admiration makes honest and useful work seem degraded. "During the predatory culture", Veblen wrote, "labour comes to be associated in men's habits of thought with weakness and subjugation to a master. It is therefore a mark of inferiority, and therefore comes to be accounted to be unworthy of man in his best estate. By virtue of this tradition, labour is felt to be debasing, and this tradition has never died out. On the contrary, with the advance of social differentiation it has acquired the axiomatic force of ancient and unquestioned prescription."

"In order to gain and hold the esteem of men it is not sufficient merely to possess wealth or power. The wealth or power must be put in evidence, for esteem is awarded only on evidence. It is felt by all persons of refined taste that a spiritual contamination is inseparable from certain offices that are conventionally required of servants. Vulgar surroundings, mean (that is to say, inexpensive) habitations, and vulgarly productive occupations are unhesitatingly condemned and avoided. They are incompatible with life on a satisfactory spiritual plane - with 'high thinking'."

"...The performance of labour has been accepted as a conventional evidence of inferior force, therefore it comes by itself, by a mental shortcut, to be regarded as intrinsically base."

"The normal and characteristic occupations of the [leisure] class are... government, war, sports, and devout observances... At this as at any other cultural stage, government and war are, at least in part, carried out for the pecuniary gain of those who engage in them, but it is gain obtained by the honourable method of seizure and conversion."

Veblen also remarks that "It is true of dress even in a higher degree than of most items of consumption, that people will undergo a very considerable degree of privation in the comforts or the necessities of life in order to afford what is considered a decent amount of wasteful consumption; so that it is by no means an uncommon occurrence, in an inclement climate, for people to go ill clad in order to appear well dressed."

The sensation caused by the publication of Veblen's book, and the fact that his phrase, "conspicuous consumption", has become part of our language, indicate that his theory did not completely miss its mark. In fact, modern advertisers seem to be following Veblen's advice: Realizing that much of the output of our economy will be used for the purpose of establishing the social status of consumers, advertising agencies hire psychologists to appeal to the consumer's longing for a higher social position.

When possessions are used for the purpose of social competition, demand has no natural upper limit; it is then limited only by the size of the human ego, which, as we know, is boundless. This would be all to the good if unlimited economic growth were desirable. But today, when further growth implies future collapse, industrial society urgently needs

to find new values to replace our worship of power, our restless chase after excitement, and our admiration of excessive consumption.

C.16 Gandhi as an economist

If humans are to achieve a stable society in the distant future, it will be necessary for them to become modest in their economic behavior and peaceful in their politics. For both modesty and peace, Gandhi is useful as a source of ideas.

Mohandas Karamchand Gandhi was born in 1869 in Porbandar, India. His family belonged to the Hindu caste of shopkeepers. (In Gujarati "Gandhi" means "grocer".) However, the family had risen in status, and Gandhi's father, grandfather, and uncle had all served as prime ministers of small principalities in western India.

In 1888, Gandhi sailed for England, where he spent three years studying law at the Inner Temple in London. Before he left India, his mother had made him take a solemn oath not to touch women, wine, or meat. He thus came into contact with the English vegetarians, who included Sir Edward Arnold (translator of the Bhagavad Gita), the Theosophists Madame Blavatski and Annie Besant, and the Fabians. Contact with this idealistic group of social critics and experimenters helped to cure Gandhi of his painful shyness, and it also developed his taste for social reform and experimentation.

Gandhi's exceptionally sweet and honest character won him many friends in England, and he encountered no racial prejudice at all. However, when he traveled to Pretoria in South Africa a few years later, he experienced racism in its worst form. Although he was meticulously well dressed in an English frock coat, and in possession of a first-class ticket, Gandhi was given the choice between traveling third class or being thrown off the train. (He chose the second alternative.) Later in the journey he was beaten by a coach driver because he insisted on his right to sit as a passenger rather than taking a humiliating position on the footboard of the coach.

The legal case which had brought Gandhi to South Africa was a dispute between a wealthy Indian merchant, Dada Abdullah Seth, and his relative, Seth Tyeb (who had refused to pay a debt of 40,000 pounds, in those days a huge sum). Gandhi succeeded in reconciling these two relatives, and he persuaded them to settle their differences out of court. Later he wrote about this experience:

"Both were happy with this result, and both rose in public estimation. My joy was boundless. I had learnt the true practice of law. I had learnt to find out the better side of human nature and to enter men's hearts. I realized that the true function of a lawyer was to unite parties riven asunder. The lesson was so indelibly burnt into me that a large part of my time during my twenty years of practice as a lawyer was occupied in bringing about compromises of hundreds of cases. I lost nothing thereby - not even money, certainly not my soul."

Gandhi was about to return to India after the settlement of the case, but at a farewell party given by Abdullah Seth, he learned of a bill before the legislature which would deprive Indians in South Africa of their right to vote. He decided to stay and fight against the bill.

Gandhi spent the next twenty years in South Africa, becoming the leader of a struggle for the civil rights of the Indian community. In this struggle he tried "...to find the better side of human nature and to enter men's hearts." Gandhi's stay in England had given him a glimpse of English liberalism and English faith in just laws. He felt confident that if the general public in England could be made aware of gross injustices in any part of the British Empire, reform would follow. He therefore organized non-violent protests in which the protesters sacrificed themselves so as to show as vividly as possible the injustice of an existing law. For example, when the government ruled that Hindu, Muslim and Parsi marriages had no legal standing, Gandhi and his followers voluntarily went to prison for ignoring the ruling.

Gandhi used two words to describe this form of protest: "satyagraha" (the force of truth) and "ahimsa" (non-violence). Of these he later wrote: "I have nothing new to teach the world. Truth and non-violence are as old as the hills. All that I have done is to try experiments in both on as vast a scale as I could. In so doing, I sometimes erred and learnt by my errors. Life and its problems have thus become to me so many experiments in the practice of truth and non-violence."

In his autobiography, Gandhi says: "Three moderns have left a deep impression on my life and captivated me: Raychandbhai (the Indian philosopher and poet) by his living contact; Tolstoy by his book 'The Kingdom of God is Within You'; and Ruskin by his book 'Unto This Last'."

Ruskin's book, "Unto This Last", which Gandhi read in 1904, is a criticism of modern industrial society. Ruskin believed that friendships and warm interpersonal relationships are a form of wealth that economists have failed to consider. He felt that warm human contacts are most easily achieved in small agricultural communities, and that therefore the modern tendency towards centralization and industrialization may be a step backward in terms of human happiness. While still in South Africa, Gandhi founded two religious Utopian communities based on the ideas of Tolstoy and Ruskin. Phoenix Farm (1904) and Tolstoy Farm (1910). At this time he also took an oath of chastity ("bramacharya"), partly because his wife was unwell and he wished to protect her from further pregnancies, and partly in order to devote himself more completely to the struggle for civil rights.

Because of his growing fame as the leader of the Indian civil rights movement in South Africa, Gandhi was persuaded to return to India in 1914 and to take up the cause of Indian home rule. In order to reacquaint himself with conditions in India, he traveled tirelessly, now always going third class as a matter of principle.

During the next few years, Gandhi worked to reshape the Congress Party into an organization which represented not only India's Anglicized upper middle class but also the millions of uneducated villagers who were suffering under an almost intolerable burden of poverty and disease. In order to identify himself with the poorest of India's people, Gandhi began to wear only a white loincloth made of rough homespun cotton. He traveled to the remotest villages, recruiting new members for the Congress Party, preaching non-violence and "firmness in the truth", and becoming known for his voluntary poverty and humility. The villagers who flocked to see him began to call him "Mahatma" (Great Soul).

Disturbed by the spectacle of unemployment and poverty in the villages, Gandhi urged

Figure C.16: **Gandhi and his wife Kasturbhai in 1902.**

the people of India to stop buying imported goods, especially cloth, and to make their own. He advocated the reintroduction of the spinning wheel into village life, and he often spent some hours spinning himself. The spinning wheel became a symbol of the Indian independence movement, and was later incorporated into the Indian flag.

The movement for boycotting British goods was called the "Swadeshi movement". The word Swadeshi derives from two Sanskrit roots: *Swa*, meaning self, and *Desh*, meaning country. Gandhi described Swadeshi as "a call to the consumer to be aware of the violence he is causing by supporting those industries that result in poverty, harm to the workers and to humans or other creatures."

Gandhi tried to reconstruct the crafts and self-reliance of village life that he felt had been destroyed by the colonial system. "I would say that if the village perishes India will perish too", he wrote, "India will be no more India. Her own mission in the world will get lost. The revival of the village is only possible when it is no more exploited. Industrialization on a mass scale will necessarily lead to passive or active exploitation of the villagers as problems of competition and marketing come in. Therefore we have to concentrate on the village being self-contained, manufacturing mainly for use. Provided this character of the village industry is maintained, there would be no objection to villagers using even the modern machines that they can make and can afford to use. Only they should not be used as a means of exploitation by others."

"You cannot build nonviolence on a factory civilization, but it can be built on self-contained villages... Rural economy as I have conceived it, eschews exploitation altogether, and exploitation is the essence of violence... We have to make a choice between India of the villages that are as ancient as herself and India of the cities which are a creation of foreign domination..."

"Machinery has its place; it has come to stay. But it must not be allowed to displace

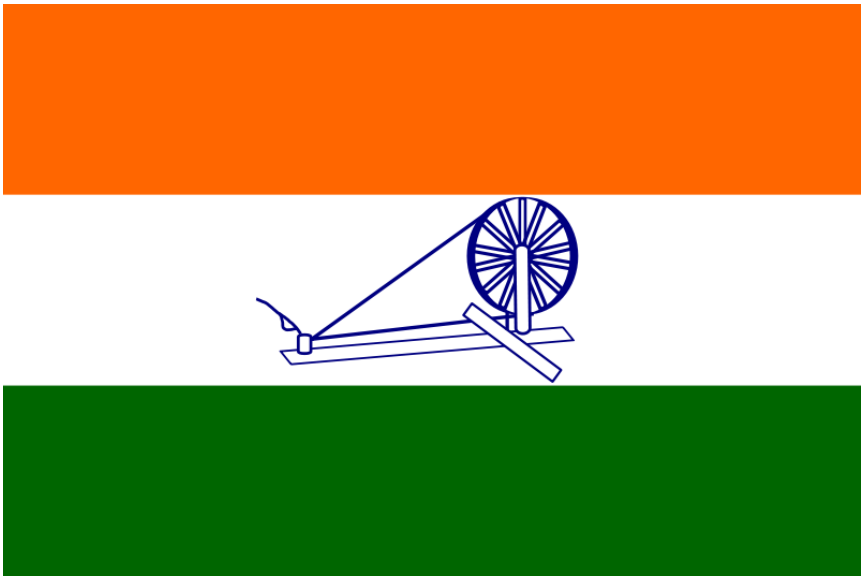

Figure C.17: **Gandhi's spinning wheel was incorporated into the flag of the Congress Party and later into the national flag of an independent India.**

necessary human labour. An improved plow is a good thing. But if by some chances, one man could plow up, by some mechanical invention of his, the whole of the land of India, and control all the agricultural produce, and if the millions had no other occupation, they would starve, and being idle, they would become dunces, as many have already become. There is hourly danger of many being reduced to that unenviable state."

In these passages we see Gandhi not merely as a pioneer of nonviolence; we see him also as an economist. Faced with misery and unemployment produced by machines, Gandhi tells us that social goals must take precedence over blind market mechanisms. If machines are causing unemployment, we can, if we wish, and use labor-intensive methods instead. With Gandhi, the free market is not sacred - we can do as we wish, and maximize human happiness, rather than maximizing production and profits.

Gandhi also organized many demonstrations whose purpose was to show the British public that although the British raj gave India many benefits, the toll exacted was too high, not only in terms of money, but also in terms of India's self-respect and self-sufficiency. All of Gandhi's demonstrations were designed to underline this fact. For example, in 1930 Gandhi organized a civil-disobedience campaign against the salt laws. The salt laws gave the Imperial government a monopoly and prevented Indians from making their own salt by evaporating sea water. The majority of Indians were poor farmers who worked long hours in extreme heat, and salt was as much a necessity to them as bread. The tax on salt was essentially a tax on the sweat of the farmers.

Before launching his campaign, Gandhi sent a polite letter to the Viceroy, Lord Irwin, explaining his reasons for believing that the salt laws were unjust, and announcing his intention of disregarding them unless they were repealed. Then, on March 12 1930, Gandhi

and many of his followers, accompanied by several press correspondents, started on a march to the sea to carry out their intention of turning themselves into criminals by making salt. Every day, Gandhi led the procession about 12 miles, stopping at villages in the evenings to hold prayer meetings. Many of the villagers joined the march, while others cast flower petals in Gandhi's path or sprinkled water on his path to settle the dust.

On April 5 the marchers arrived at the sea, where they spent the night in prayer on the beach. In the morning they began to make salt by wading into the sea, filling pans with water, and letting it evaporate in the sun. Not much salt was made in this way, but Gandhi's action had a strong symbolic power. A wave of non-violent civil disobedience demonstrations swept over India, so extensive and widespread that the Imperial government, in danger of losing control of the country, decided to arrest as many of the demonstrators as possible. By midsummer, Gandhi and a hundred thousand of his followers were in prison, but nevertheless the civil disobedience demonstrations continued.

In January, 1931, Gandhi was released from prison and invited to the Viceroy's palace to talk with Lord Irwin. They reached a compromise agreement: Gandhi was to call off the demonstrations and would attend a Round Table Conference in London to discuss Indian home rule, while Lord Irwin agreed to release the prisoners and would change the salt laws so that Indians living near to the coast could make their own salt.

The salt march was typical of Gandhi's non-violent methods. Throughout the demonstrations he tried to maintain a friendly attitude towards his opponents, avoiding escalation of the conflict. Thus at the end of the demonstrations, the atmosphere was one in which a fair compromise solution could be reached. Whenever he was in prison, Gandhi regarded his jailers as his hosts. Once, when he was imprisoned in South Africa, he used the time to make a pair of sandals, which he sent to General Smuts, the leader of the South African government. Thus Gandhi put into practice the Christian principle, "Love your enemies; do good to them that hate you."

Gandhi's importance lies in the fact that he was a major political leader who sincerely tried to put into practice the ethical principles of religion. In his autobiography Gandhi says: "I can say without the slightest hesitation, and yet with all humility, that those who say that religion has nothing to do with politics do not know what religion means."

Gandhi believed that human nature is essentially good, and that it is our task to find and encourage whatever is good in the character of others. During the period when he practiced as a lawyer, Gandhi's aim was "to unite parties riven asunder," and this was also his aim as a politician. In order for reconciliation to be possible in politics, it is necessary to avoid escalation of conflicts. Therefore Gandhi used non-violent methods, relying only on the force of truth. "It is my firm conviction," he wrote, "that nothing can be built on violence."

To the insidious argument that "the end justifies the means," Gandhi answered firmly: "They say 'means are after all means'. I would say 'means are after all everything'. As the means, so the end. Indeed the Creator has given us control (and that very limited) over means, none over end. ... The means may be likened to a seed, and the end to a tree; and there is the same inviolable connection between the means and the end as there is between the seed and the tree. Means and end are convertible terms in my philosophy of

life." In other words, a dirty method produces a dirty result; killing produces more killing; hate leads to more hate. But there are positive feedback loops as well as negative ones. A kind act produces a kind response; a generous gesture is returned; hospitality results in reflected hospitality. Hindus and Buddhists call this principle "the law of karma".

Gandhi believed that the use of violent means must inevitably contaminate the end achieved. Because Gandhi's methods were based on love, understanding, forgiveness and reconciliation, the non-violent revolution which he led left very little enmity in its wake. When India finally achieved its independence from England, the two countries parted company without excessive bitterness. India retained many of the good ideas which the English had brought - for example the tradition of parliamentary democracy - and the two countries continued to have close cultural and economic ties.

Mahatma Gandhi was assassinated by a Hindu extremist on January 30, 1948. After his death, someone collected and photographed all his worldly goods. These consisted of a pair of glasses, a pair of sandals and a white homespun loincloth. Here, as in the Swadeshi movement, we see Gandhi as a pioneer of economics. He deliberately reduced his possessions to an absolute minimum in order to demonstrate that there is no connection between personal merit and material goods. Like Veblen, Mahatma Gandhi told us that we must stop using material goods as a means of social competition. We must start to judge people not by what they have, but by what they are.

C.17 Thoreau

In the distant future (and perhaps even in the not-so-distant future) industrial civilization will need to abandon its relentless pursuit of unnecessary material goods and economic growth. Modern society will need to re-establish a balanced and harmonious relationship with nature. In pre-industrial societies harmony with nature is usually a part of the cultural tradition. In our own time, the same principle has become central to the ecological counter-culture while the main-stream culture thunders blindly ahead, addicted to wealth, power and growth.

In the 19th century the American writer, Henry David Thoreau (1817-1862), pioneered the concept of a simple life, in harmony with nature. Today, his classic book, *Walden*, has become a symbol for the principles of ecology, simplicity, and respect for nature.

Thoreau was born in Concord Massachusetts, and he attended Harvard from 1833 to 1837. After graduation, he returned home, worked in his family's pencil factory, did odd jobs, and for three years taught in a progressive school founded by himself and his older brother, John. When John died of lockjaw in 1842, Henry David was so saddened that he felt unable to continue the school alone.

Thoreau refused to pay his poll tax because of his opposition to the Mexican War and to the institution of slavery. Because of his refusal to pay the tax (which was in fact a very small amount) he spent a night in prison. To Thoreau's irritation, his family paid the poll tax for him and he was released. He then wrote down his ideas on the subject in an essay entitled *The Duty of Civil Disobedience*, where he maintains that each person has a

duty to follow his own individual conscience even when it conflicts with the orders of his government. "Under a government that which imprisons any unjustly", Thoreau wrote, "the true place for a just man is in prison." *Civil Disobedience* influenced Tolstoy, Gandhi and Martin Luther King, and it anticipated the Nüremberg Principles.

Thoreau became the friend and companion of the transcendentalist writer Ralph Waldo Emerson (1803-1882), who introduced him to a circle of writers and thinkers that included Ellery Channing, Margaret Fuller and Nathanial Hawthorne.

Nathanial Hawthorne described Thoreau in the following words: "Mr. Thorow [sic] is a keen and delicate observer of nature - a genuine observer, which, I suspect, is almost as rare a character as even an original poet; and Nature, in return for his love, seems to adopt him as her especial child, and shows him secrets which few others are allowed to witness. He is familiar with beast, fish, fowl, and reptile, and has strange stories to tell of adventures, and friendly passages with these lower brethren of mortality. Herb and flower, likewise, wherever they grow, whether in garden, or wild wood, are his familiar friends. He is also on intimate terms with the clouds and can tell the portents of storms. It is a characteristic trait, that he has a great regard for the memory of the Indian tribes, whose wild life would have suited him so well; and strange to say, he seldom walks over a plowed field without picking up an arrow-point, a spear-head, or other relic of the red men - as if their spirits willed him to be the inheritor of their simple wealth."

At Emerson's suggestion, Thoreau opened a journal, in which he recorded his observations concerning nature and his other thoughts. Ultimately the journal contained more than 2 million words. Thoreau drew on his journal when writing his books and essays, and in recent years, many previously unpublished parts of his journal have been printed.

From 1845 until 1847, Thoreau lived in a tiny cabin that he built with his own hands. The cabin was in a second-growth forest beside Walden Pond in Concord, on land that belonged to Emerson. Thoreau regarded his life there as an experiment in simple living. He described his life in the forest and his reasons for being there in his book *Walden*, which was published in 1854. The book is arranged according to seasons, so that the two-year sojourn appears compressed into a single year.

"Most of the luxuries", Thoreau wrote, "and many of the so-called comforts of life, are not only not indispensable, but positive hindrances to the elevation of mankind. With respect to luxuries, the wisest have ever lived a more simple and meager life than the poor. The ancient philosophers, Chinese, Hindoo, Persian, and Greek, were a class than which none has been poorer in outward riches, none so rich in inward."

Elsewhere in *Walden*, Thoreau remarks, "It is never too late to give up your prejudices", and he also says, "Why should we be in such desperate haste to succeed, and in such desperate enterprises? If a man does not keep pace with his companions, perhaps it is because he hears a different drummer." Other favorite quotations from Thoreau include "Rather than love, than money, than fame, give me truth", "Beware of all enterprises that require new clothes", "Most men lead lives of quiet desperation" and "Men have become tools of their tools."

Towards the end of his life, when he was very ill, someone asked Thoreau whether he had made his peace with God. "We never quarreled", he answered.

Figure C.18: **Henry David Thoreau, 1817-1862.**

Thoreau's closeness to nature can be seen from the following passage, written by his friend Frederick Willis, who visited him at Walden Pond in 1847, together with the Alcott family: "He was talking to Mr. Alcott of the wild flowers in Walden woods when, suddenly stopping, he said: 'Keep very still and I will show you my family.' Stepping quickly outside the cabin door, he gave a low and curious whistle; immediately a woodchuck came running towards him from a nearby burrow. With varying note, yet still low and strange, a pair of gray squirrels were summoned and approached him fearlessly. With still another note several birds, including two crows flew towards him, one of the crows nestling upon his shoulder. I remember that it was the crow resting close to his head that made the most vivid impression on me, knowing how fearful of man this bird is. He fed them all from his hand, taking food from his pocket, and petted them gently before our delighted gaze; and then dismissed them by different whistling, always strange and low and short, each wild thing departing instantly at hearing his special signal."

In an essay published by the *Atlantic Monthly* in 1853, Thoreau described a pine tree in Maine with the words: "It is as immortal as I am, and perchance will go to as high a heaven, there to tower above me still." However, the editor (James Russell Lowell) considered the sentence to be blasphemous, and removed it from Thoreau's essay before publication.

In one of his essays, Thoreau wrote: "If a man walk in the woods for love of them half of each day, he is in danger of being regarded as a loafer; but if he spends his whole day as a speculator, shearing off those woods and making the earth bald before her time, he is esteemed an industrious and enterprising citizen."

C.18 The counter-culture

Say's Law asserts that "Supply creates its own demand". Jean-Baptiste Say's basis for this proposition was the assumption that a consumer's desire for goods is infinite. He combined this assumption with the observation that the wages paid for the production of goods will provide money enough to buy back the goods, even if the amount involved increases without limit. Comforted by Say's "law", and by the observation that people in industrial societies do indeed consume far more than they actually need, economists continue to pursue economic growth as though it were the Holy Grail. We do indeed devote much of our efforts to "making the earth bald before her time".

As things are today, the advertising industry, which is part of the mainstream culture, whips demand towards ever higher levels by exploiting our tendency to use material goods for the purpose of social competition. Meanwhile, a small but significant counter-culture has realized that unlimited economic growth will lead to ecological disaster unless we stop in time.

In the 1960's, a counter-culture developed in the United States, partly as a reaction against the Vietnam War and partly as a reaction against consumerism. It seemed to young people that they were being offered a possession-centered way of life that they did not want, and that they were being asked to participate in a war that they thought was immoral.

In 1964, a free speech movement began on the campus of the University of California in Berkeley. Students demanded that the university administration should lift a ban that it had imposed on on-campus political activities. Student movements elsewhere in the United States and in Europe echoed the Berkeley protests throughout the late 1960's and early 1970's.

Mario Savo, one of the leaders of the Berkeley free speech movement, compared the Establishment to an enormous anti-human machine: "There is a time when the operation of the machine becomes so odious, makes you so sick at heart, that you can't take part; you can't even passively take part, and you've got to put your bodies upon the gears and upon the wheels, upon the levers, upon all the apparatus, and you've got to make it stop. And you've got to indicate to the people who run it, to the people who own it, that unless you're free, the machine will be prevented from working at all."

The Greening of America, by Charles Reich, describes the youth-centered counter-culture: "Industrialism produced a new man...", Reich wrote, "one adapted to the demands of the machine. In contrast, today's emerging consciousness seeks a new knowledge of what it means to be human, in order that the machine, having been built, may now be turned to human ends; in order that man once more can become a creative force, renewing and creating his own life and thus giving life back to society."

C.19 The Brundtland Report

In 1972, the United Nations Conference on the Human Environment took place in Stockholm. In a 1983 follow-up to the Stockholm conference, the General Assembly of the UN adopted a resolution (A/38/161) establishing the World Commission on Environment and Development. It is usually known as the Brundtland Commission after the name of its Chair, Dr. Gro Harlem Brundtland, who was at the time the Prime Minister of Norway. The report of the Brundtland Commission, entitled *Our Common Future*, was submitted to the United Nations in 1987.

In the words of Dr. Brundtland, the goal of the report was "to help define shared perceptions of long-term environmental issues and the appropriate efforts needed to deal successfully with the problems of protecting and enhancing the environment, a long-term agenda for action during the coming decades..."

One of the key concepts of the Brundtland Report was "sustainable development". The Report offered the following definition: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The Brundtland Commission's key concepts for sustainability were as follows:

1. Today's needs should not compromise the ability of future generations to meet their needs.

2. A direct link exists between the economy and the environment.

Figure C.19: **Gro Harlem Brundtland**

3. The needs of the poor in all nations must be met.

4. In order for the environment to be protected, the economic conditions of the world's poor must be improved.

5. In all our actions, we must consider the impact upon future generations.

The Brundtland Commission's report examines the question of whether the earth can support a population of 10 billion people without the collapse of the ecological systems on which all life depends. The report states that the data "suggest that meeting the food requirements of an ultimate world population of around 10 billion would require some changes in food habits, as well as greatly improving the efficiency of traditional agriculture."

C.20 The Earth Summit at Rio

The Brundtland Report served as a preparation for the United Nations Conference on Environment and Development, which took place from the 3rd to the 14th of June, 1992 in Rio de Janeiro. The conference, informally called the "Earth Summit", was unprecedented in its size and significance. 172 governments participated, including 108 heads of state or government. 17,000 people attended the Earth Summit, including 2,400 representatives of NGO's. An estimated 10,000 journalists covered the conference.

The Earth Summit at Rio ought to have been a turning point in the relationship between humans and the global environment. However, despite the size and importance of the conference, and despite the hopes of most of the participants, the the Earth Summit did not result in the changes in laws and lifestyles that will be needed to establish long-term sustainability.

Two basic problems are leading to the destruction of the global environment - excessive population growth in the developing South, and excessive economic growth and overconsumption in the industrial North. Political and religious pressures prevented overpopulation from being named at Rio as one of the root causes of environmental degradation. Political pressures also prevented the necessary changes in laws and lifestyles from being made in the North.

Nevertheless, considerable progress was made at Rio. The resulting documents included Agenda 21 (an environmental agenda for the 21st century), the Rio Declaration on Environment and Development, the Statement on Forest Principles, the United Nations Framework Convention on Climate Change and the United Nations Convention on Biological Diversity. Later the Earth Charter was developed by some of the leaders who met in Rio.

Agenda 21

The first few chapters of Agenda 21 are as follows:

1. Preamble
2. International cooperation to accelerate sustainable development in developing countries and related domestic policies
3. Combating poverty
4. Changing consumption patterns
5. Demographic dynamics and sustainability
6. Protecting and promoting human health conditions
7. Promoting sustainable human settlement development
8. Integrating environment and development in decision-making
9. Protecting the atmosphere
10. Integrated approach to the planning and management of land resources
11. Combating deforestation
12. Managing fragile ecosystems; sustainable mountain development
13. Conservation of biological diversity
14. Environmentally sound management of biotechnology
15. Protection of the oceans

The good intentions of the authors shine from this list! It was a major victory to have Agenda 21 adopted as the official policy of the United Nations. Close examination reveals many political compromises in the wording the conclusions, but the idealism of the document is not entirely lost.

Agenda 21, touches (very lightly!) on the root causes of environmental degradation. In Section 4.6, one finds the extremely weak statement: "Some economists are questioning traditional concepts of economic growth and underlining the importance of pursuing economic objectives that take into account of the full value of natural resource capital. More needs to be known about the role of consumption in relation to economic growth and population dynamics in order to formulate coherent international and national policies." However, in Section 5.3, a clearer statement of the basic problem appears: "The growth of world population and production, combined with unsustainable consumption patterns, places increasingly severe stress on the life-supporting systems of our planet."

C.21 The transition from growth to a steady state - minimizing the trauma

According to Adam Smith, the free market is the dynamo of economic growth. The true entrepreneur does not indulge in luxuries for himself and his family, but reinvests his profits, with the result that his business or factory grows larger, producing still more profits, which he again reinvests, and so on. This is indeed the formula for exponential economic growth.

Economists (with a few notable exceptions) have long behaved as though growth were synonymous with economic health. If the gross national product of a country increases steadily by 4% per year, most economists express approval and say that the economy is healthy. If the economy could be made to grow still faster (they maintain), it would be still more healthy. If the growth rate should fall, economic illness would be diagnosed. However, the basic idea of Malthus is applicable to exponential increase of any kind. It is obvious that on a finite Earth, neither population growth nor economic growth can continue indefinitely.

A "healthy" economic growth rate of 4% per year corresponds to an increase by a factor of 50 in a century, by a factor of 2500 in two centuries, and by a factor of 125,000 in three centuries. No one can maintain that this type of growth is sustainable except by refusing to look more than a short distance into the future.

But *why* do most economists cling so stubbornly and blindly to the concept of growth? Why do they refuse to look more than a few years into the future? We can perhaps understand this strange self-imposed myopia by remembering some of David Ricardo's ideas: One of his most important contributions to economic theory was his analysis of rents. Ricardo considered the effects of economic expansion; and he concluded that as population increased, marginally fertile land would be forced into cultivation. The price of grain would be determined by the cost of growing it on inferior land; and the owners of better land would be able to pocket a progressively larger profit as worse and worse land

was forced into use by the demands of a growing population. Ricardo's analysis of rents for agricultural land has various generalizations; for example, a growing population also puts pressure on land used for building cities, and profits can be gained by holding such land, or through the ownership of houses in growing cities. In general, in a growing economy, investments are likely to be rewarded. In a stationary or contracting economy, the stock market may crash.

Considerations like those just discussed make it easy to understand why economists are biased in favor of growth. However, we are now entering a period where biological and physical constraints will soon put an end to economic growth.

Instead of burning our tropical forests, it might be wise for us to burn our books on growth-oriented economics! An entirely new form of economics is needed today - not the empty-world economics of Adam Smith, but what might be called "full-world economics", or "steady-state economics".

The present use of resources by the industrialized countries is extremely wasteful. A growing national economy must, at some point, exceed the real needs of the citizens. It has been the habit of the developed countries to create artificial needs by means of advertising, in order to allow economies to grow beyond the point where all real needs have been met; but this extra growth is wasteful, and in the future it will be important not to waste the earth's diminishing supply of non-renewable resources.

Thus, the times in which we live present a challenge: We need a revolution in economic thought. We must develop a new form of economics, taking into account the realities of the world's present situation - an economics based on real needs and on a sustainable equilibrium with the environment, not on the thoughtless assumption that growth can continue forever.

Adam Smith was perfectly correct in saying that the free market is the dynamo of economic growth; but exponential growth of human population and economic activity have brought us, in a surprisingly short time, from the empty-world situation in which he lived to a full-world situation. In today's world, we are pressing against the absolute limits of the earth's carrying capacity, and further growth carries with it the danger of future collapse. Full-world economics, the economics of the future, will no longer be able to rely on growth to give profits to stockbrokers or to solve problems of unemployment or to alleviate poverty. In the long run, growth of any kind is not sustainable; and we are now nearing its sustainable limits.

Like a speeding bus headed for a brick wall, the earth's rapidly-growing population of humans and its rapidly-growing economic activity are headed for a collision with a very solid barrier - the carrying capacity of the global environment. As in the case of the bus and the wall, the correct response to the situation is to apply the brakes in time - but fear prevents us from doing this. What will happen if we slow down very suddenly? Will not many of the passengers be injured? Undoubtedly. But what will happen if we hit the wall at full speed? Perhaps it would be wise, after all, to apply the brakes!

The memory of the great depression of 1929 makes us fear the consequences of an economic slowdown, especially since unemployment is already a serious problem in many parts of the world. Although the history of the 1929 depression is frightening, it may

nevertheless be useful to look at the measures which were used then to bring the global economy back to its feet. A similar level of governmental responsibility may help us to avoid some of the more painful consequences of the necessary transition from the economics of growth to steady-state economics.

In the United States, President Franklin D. Roosevelt was faced with the difficult problems of the depression during his first few years in office. Roosevelt introduced a number of special governmental programs, such as the WPA, the Civilian Construction Corps and the Tennessee Valley Authority, which were designed to create new jobs on projects directed towards socially useful goals - building highways, airfields, auditoriums, harbors, housing projects, schools and dams. The English economist John Maynard Keynes, (1883-1946), provided an analysis of the factors that had caused the 1929 depression, and a theoretical justification of Roosevelt's policies.

The transition to a sustainable global society will require a similar level of governmental responsibility, although the measures needed are not the same as those which Roosevelt used to end the great depression. Despite the burst of faith in the free market which has followed the end of the Cold War, it seems unlikely that market mechanisms alone will be sufficient to solve problems of unemployment in the long-range future, or to achieve conservation of land, natural resources and environment.

Figure C.20: **Franklin D. Roosevelt (1882-1945) with his dog Fala and Ruthie Bie at Hilltop in 1941. Roosevelt served as President of the United States from 1933 to 1945, and was starting his 4th term when he died. Although crippled by polio, he managed to convey an image of dynamism and confidence.**

C.22 Keynesian economics

In December, 1933, Keynes wrote to Franklin D. Roosevelt: "Dear Mr. President, You have made yourself the Trustee for those in every country who seek to mend the evils of our condition by reasoned experiment within the framework of the existing social system. If you fail, rational change will be gravely prejudiced throughout the world, leaving orthodoxy and revolution to fight it out. But if you succeed, new and bolder methods will be tried everywhere, and we may date the first chapter of a new economic era from your accession to office..."

"...Thus as the prime mover in the first stage of the technique of recovery I lay overwhelming emphasis on the increase of national purchasing power resulting from governmental expenditure which is financed by Loans and not by taxing present incomes. Nothing else counts in comparison with this. In a boom inflation can be caused by allowing unlimited credit to support the excited enthusiasm of business speculators. But in a slump governmental Loan expenditure is the only sure means of securing quickly a rising output at rising prices. That is why war has always caused intense industrial activity. In the past orthodox finance has regarded war as the only legitimate excuse for creating employment by governmental expenditure. You, Mr. President, having cast off such fetters, are free to engage in the interests of peace and prosperity the technique which hitherto has only been allowed to serve the purposes of war and destruction."

John Maynard Keynes (1883-1946), the author of this letter to Roosevelt, was the son of the Cambridge University economist and logician, Neville Keynes. After graduating from Eton and studying economics at King's College, Cambridge, Keynes spent a few years as a civil servant in the India Office. In 1909, he returned to Cambridge as a Fellow of King's College. He became a member of the "Bloomsbury Group", a collection of intellectual friends that included Virginia and Leonard Woolf, E.M. Forster, Clive and Vanessa Bell, Duncan Grant, Lytton Strachy, Roger Fry, and Bertrand Russell. In 1911, Keynes became the editor of the *Economic Journal*, a position that he retained almost until the end of his life.

In 1918, Keynes married the Russian ballerina Lydia Lopokova. They met at a party given by the Sitwells. Lydia was struggling to learn English, and one of her more interesting remarks was, "I dislike being in the country in August because my legs get so bitten by barristers". To everyone's surprise, Lydia proved to be the perfect wife for Keynes, encouraging his wide range of cultural interests. He and Lydia did much to develop the Cambridge Arts Theatre. Lydia maintained her interest in the ballet, although she no longer danced professionally. Visitors to the couple's house occasionally heard formidable thumpings from an upper room, and they realized that Lydia was practicing.

During World War I, Keynes worked in the British Treasury, helping to find ways to finance the war. In 1919, he was sent to the peace conference at Versailles as a representative of the Treasury. Keynes recognized the disastrous economic consequences that would follow from the Treaty of Versailles, and returning to Cambridge, he wrote *The Economic Consequences of the Peace* (1919). "It is an extraordinary fact", Keynes wrote, "that the fundamental problems of a Europe starving and disintegrating before their eyes, was the

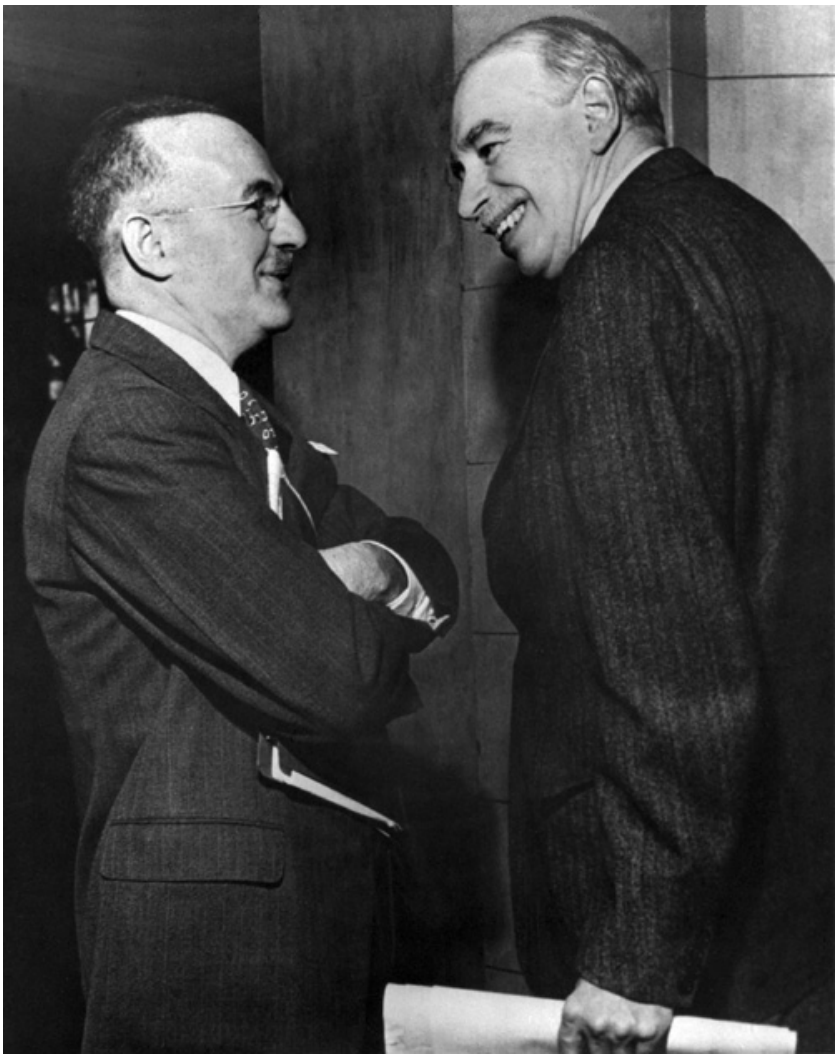

Figure C.21: **John Maynard Keynes (right) with Harry Dexter White at the Bretton Woods Conference. Keynes was an extremely tall man - 6 feet and 6 inches tall, i.e. 198 cm. Heart problems caused his early death.**

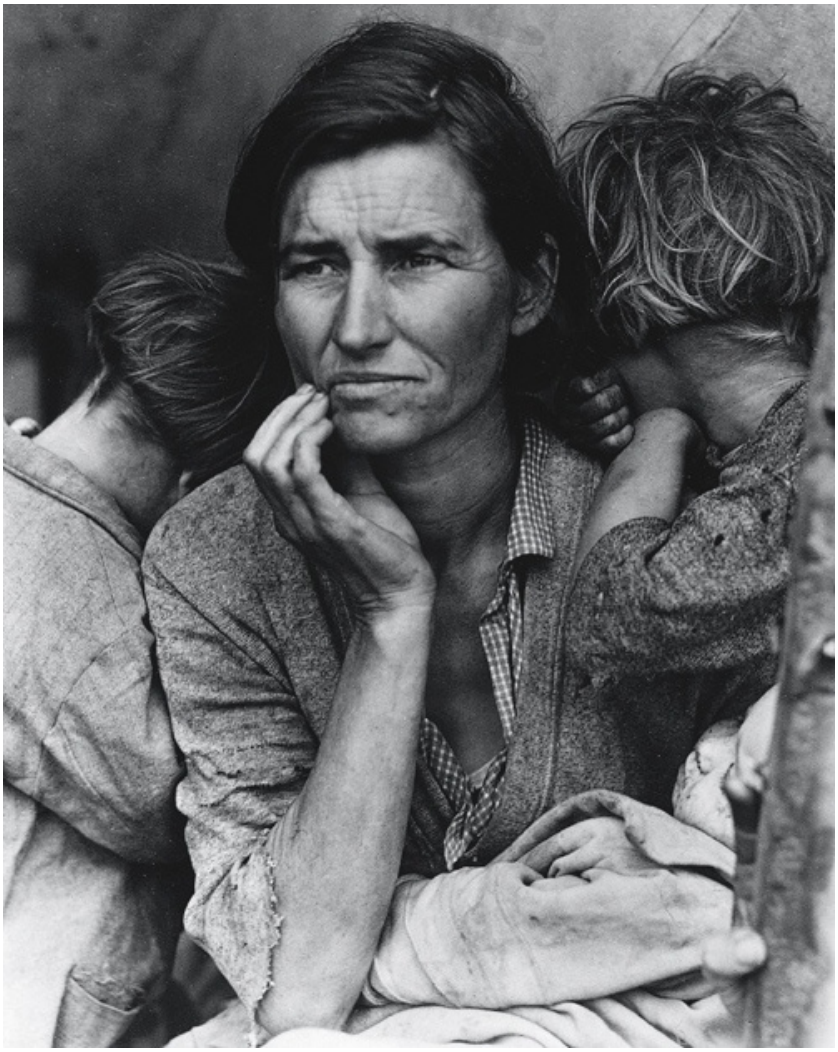

Figure C.22: **Migrant Mother, a photograph by Dorthea Lange, shows a destitute pea picker in California in 1936, during the Great Depression.**

one question in which it was impossible to arouse the interest of the [Council of] Four."

The book became a best seller and was very influential in shaping public opinion, both in England and in the United States. In his book, Keynes predicted that the reparations imposed against Germany at Versailles would cause economic ruin. He advocated instead a loan system to rebuild postwar Europe. The plan advocated by Keynes was similar to the Marshall Plan that followed World War II. Had it been put into effect in 1919, it might have prevented the Second World War.

In 1936, Keynes published his magnum opus, *General Theory of Employment, Interest and Money*. In this book, he provided a theoretical explanation for the fact that the great depression showed no tendency to right itself, as well as arguments for governmental interventions to counter business cycles and to produce full employment. Once again, Keynes

had written a best-seller. His *General Theory* proved to be one of the most influential books on economics ever written.

Keynes rebelled against the ideas of the classical economists, who believed that if let entirely alone, the world economy would correct itself. The classical economists recommended that, to end the depression, labor unions should be made illegal, minimum wages and long-term wage contracts abolished, and government spending curtailed (to restore business confidence). Then, they maintained, wages would fall, businessmen would hire more workers, and full employment and production would be restored. One reason for the popularity of the *General Theory* was that everyone knew the recommendations of the classical economists were bad policies. Now Keynes showed why these bad policies were also bad economics.

Keynes pointed out that a fall in wages would produce a fall in purchasing power, and hence a fall in aggregate demand. Producers would then be less able to sell their products. Thus Keynes believed that falling wages would deepen the depression, rather than ending it.

Part of Keynes' skepticism towards classical economics had to do with his criticisms of the short-term version of Say's Law, on which classical economics was based. Jean-Baptiste Say (1767-1832) believed a general glut to be impossible, since wages for the production of goods could be used by society to buy back its aggregate production. "A glut", Say wrote, "can take place only when there are too many means of production applied to one kind of product, and not enough to another."

Say considered the influence of the money supply on this process to be negligible, and he believed that the problem could be analyzed from the standpoint of barter. Say believed that no one would keep money for long. Having obtained money in a transaction, he believed, people would immediately spend it again. Thus Say did not worry about the problem of excessive saving that bothered both Malthus and Hobson.

"It is not the abundance of money", Say wrote, "but the abundance of other products in general that facilitates sales... Money performs no more than the role of a conduit in this double exchange. When the exchanges have been completed, it will be found that one has paid for products with products."

"It is worthwhile to remark", Say continued, "that a product is no sooner created than it, from that instant, affords a market for other products to the full extent of its value. When the producer has put the finishing hand to his product, he is most anxious to sell it immediately, lest its value should diminish in his hands. Nor is he less anxious to dispose of the money he may get for it; for the value of money is also perishable. But the only way to get rid of money is in the purchase some product or other. Thus the mere circumstance of creation of one product immediately opens a vent for other products."

Keynes disagreed with these conclusions in several respects. First of all, he did not believe, like Say, that the money supply played a negligible role in determining economic activity. Secondly he did not agree that the producer who has received money for his goods is necessarily "anxious to dispose of the money". As a recession deepens, the value of money in terms of goods increases, and therefore it is rational to keep money, hoping to get more goods for it at a later time. Whether it is more rational to keep money or to

spend it immediately depends on the phase of the business cycle, Keynes pointed out.

In James Mill's version, Say's Law states that "supply creates its own demand". Keynes reversed this, and maintained in a depression, the fault may be on the demand side, i.e., "demand creates supply", rather than the reverse. It is true that during the great depression, many people were in need; but need does not constitute demand in the economic sense unless it is combined with purchasing power.

Keynes (like Malthus and Hobson) believed that excessive saving could be a serious problem, capable of causing a "general glut" or depression. By excessive saving, he meant saving beyond planned investment, a condition that could be caused by falling consumer demand, overinvestment in previous years, or lack of business confidence. The classical economists believed that excessive saving would be corrected by falling interest rates. Keynes did not believe that interest rates would respond quickly enough to perform this corrective function. Instead, Keynes believed, excessive savings would be in the end corrected by the fall in aggregate income which characterizes a recession or depression. The economy would reach a new equilibrium at low levels of employment, income, investment and production. This new, undesirable equilibrium would not be self-correcting. (By calling his theory a *General Theory*, Keynes meant that he treated not only the full-employment equilibrium, but also other types of equilibria.)

Keynes believed that active government fiscal and monetary policy could be effective in combating cycles of inflation and depression. *Fiscal policy* is defined as policy regarding government expenditure, while *monetary policy* means governmental policy with respect to the money supply. Keynes advocated a counter-cyclical use of these two tools, i.e. he believed that government spending and expansionist monetary policy should be used to combat recessions and depressions, while the opposite policies should be used to cool an economy whenever it became overheated.

Keynes visited Roosevelt in Washington in 1934. Roosevelt liked him, but found his theories overly mathematical. Nevertheless Keynes ideas influenced Roosevelt's policies, especially in 1937, when a new dip in the economy occurred. Over the years, Keynes' advocacy of counter-cyclical governmental intervention has become widely accepted, especially by social-democratic governments in Europe.

The New Deal measures inaugurated by Roosevelt were only partially effective in producing full employment. The reason that they were only partially successful was that although they were designed to help business get restarted, they were viewed with hostility by the business community. This hostility prevented Roosevelt from using fiscal policy on a large enough scale to produce full employment. Also, because businessmen felt uneasy with the new political climate, business investment remained sluggish.

One of the conclusions of Keynes' *General Theory* was that investment by expanding businesses is essential to keep an economy from contracting. This conclusion is worrying, because in the future, exponential expansion of business activity will gradually become less and less possible. Thus we can visualize a future need for governmental intervention to prevent a depression.

During World War II, Keynes advice on how to finance the war effort was sought by the British government. He did as much as he could, but his activity was limited by increasing

heart problems. At the end of the war, Keynes represented England at the Breton Woods Conference, which established the World Bank and the International Monetary Fund. He received many honors - for example, he became Lord Keynes. However, his health remained unstable, and in 1946 he died of a heart attack. His life and work had produced a permanent change from the *laissez faire* economics of Adam Smith to an era of recognized governmental responsibility.

C.23 The transition to a sustainable economy

The Worldwatch Institute, Washington D.C., lists the following steps as necessary for the transition to sustainability[4]:

1. Stabilizing population
2. Shifting to renewable energy
3. Increasing energy efficiency
4. Recycling resources
5. Reforestation
6. Soil Conservation

All of these steps are labor-intensive; and thus, wholehearted governmental commitment to the transition to sustainability can help to solve the problem of unemployment.

In much the same spirit that Roosevelt (with Keynes' approval) used governmental powers to end the great depression, we must now urge our governments to use their powers to promote sustainability and to reduce the trauma of the transition to a steady-state economy. For example, an increase in the taxes on fossil fuels could make a number of renewable energy technologies economically competitive; and higher taxes on motor fuels would be especially useful in promoting the necessary transition from private automobiles to bicycles and public transportation. Tax changes could also be helpful in motivating smaller families.

Governments already recognize their responsibility for education. In the future, they must also recognize their responsibility for helping young people to make a smooth transition from education to secure jobs. If jobs are scarce, work must be shared, in a spirit of solidarity, among those seeking employment; hours of work (and if necessary, living standards) must be reduced to insure a fair distribution of jobs. Market forces alone cannot achieve this. The powers of government are needed.

Economic activity is usually divided into two categories, 1) production of goods and 2) provision of services. It is the rate of production of goods that will be limited by the carrying capacity of the global environment. Services that have no environmental impact

[4]L.R. Brown and P. Shaw, 1982.

Figure C.23: **A reforestation project in Burkina Faso. Projects such as this may help the world to achieve sustainability, while simultaneously helping to solve problems of unemployment.**

will not be constrained in this way. Thus a smooth transition to a sustainable economy will involve a shift of a large fraction the work force from the production of goods to the provision of services.

In his recent popular book *The Rise of the Creative Class*, the economist Richard Florida points out that in a number of prosperous cities - for example Stockholm - a large fraction of the population is already engaged in what might be called creative work - a type of work that uses few resources, and produces few waste products - work which develops knowledge and culture rather than producing material goods. For example, producing computer software requires few resources and results in few waste products. Thus it is an activity with a very small ecological footprint. Similarly, education, research, music, literature and art are all activities that do not weigh heavily on the carrying capacity of the global environment. Florida sees this as a pattern for the future, and maintains that everyone is capable of creativity. He visualizes the transition to a sustainable future economy as one in which a large fraction of the work force moves from industrial jobs to information-related work. Meanwhile, as Florida acknowledges, industrial workers feel uneasy and threatened by such trends.

C.24 Population and goods per capita

In the distant future, the finite carrying capacity of the global environment will impose limits on the amount of resource-using and waste-generating economic activity that it will be possible for the world to sustain. The consumption of goods per capita will be equal to this limited total economic activity divided by the number of people alive at that time. Thus, our descendants will have to choose whether they want to be very numerous and very poor, or less numerous and more comfortable, or very few and very rich. Perhaps the middle way will prove to be the best.

Given the fact that environmental carrying capacity will limit the sustainable level of resource-using economic activity to a fixed amount, average wealth in the distant future will be approximately inversely proportional to population over a certain range of population values.[5]

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[5]Obviously, if the number of people is reduced to such an extent that it approaches zero, the average wealth will not approach infinity, since a certain level of population is needed to maintain a modern economy. However, if the global population becomes extremely large, the average wealth will indeed approach zero.

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Index