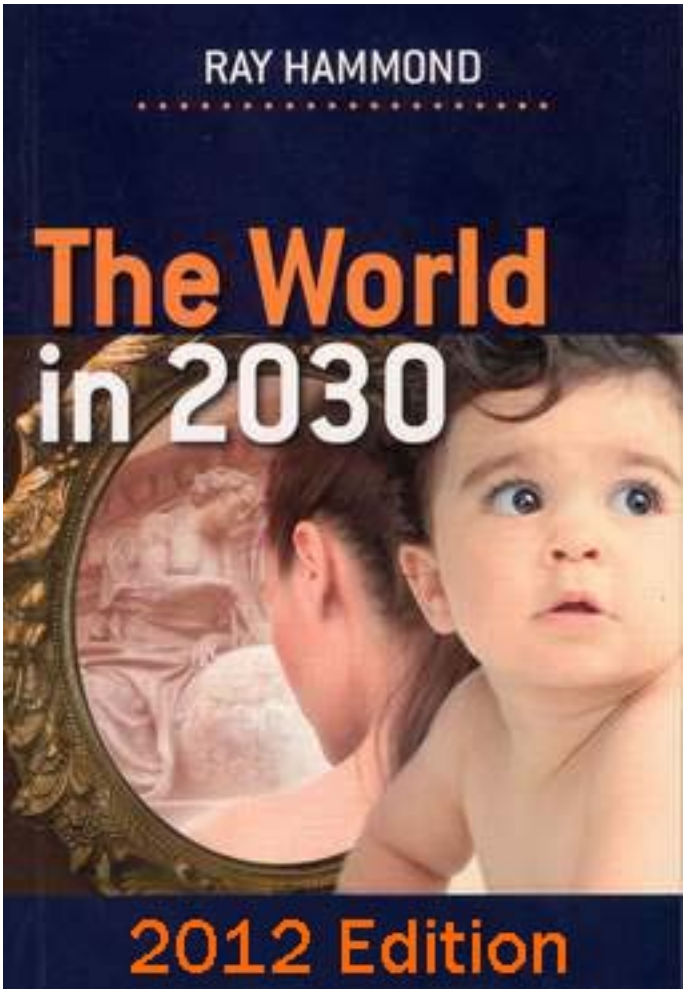

Revised And Completely Updated

FOREWORD TO THE 2012 EDITION

There have been five major global developments since I completed the first edition of this book in 2007.

The first was the global banking and credit crisis that struck in 2008. For a few weeks in September of that year it seemed possible that part of the global banking system might collapse – a scenario never previously contemplated by me, or by any other futurist. As a result, a severe Western-centric recession followed which is only now coming haltingly to an end. This was followed by serious international concerns about the integrity of the Eurozone and, in particular, worries about the (lack of) political will within the European Union to prop up the seriously weakened economies of Greece, Portugal and others.

But the credit crisis was an ‘event’, not part of a general trend and, as such, it has now largely passed. The debts taken on by nations to refinance bankrupt banks and loan providers (and other credit-dependent organizations such as auto makers) will take years to repay, but it is now clear that capitalism and the current nation-state-based economic model – shaky as it is – will survive for the foreseeable future. Indeed the great emerging economies (China, India, Brazil, etc.) hardly paused for breath during the Western-based crisis and are, once again, notching up double digit annual growth figures.

The second major development that has occurred since 2007 is the loss of momentum among global leaders to act in a concerted way to reduce the effects of global warming. The costs of tackling the credit crisis (and the resultant sovereign debt crises) have a lot of do with this loss of momentum (any action to significantly reduce greenhouse gas emissions will be expensive) but the hostile political stalemate that has existed in the U.S.A following Barack Obama’s election to office has also prevented the new president from taking a strong lead on this pressing issue – as he promised to do before his election. American politics is now so divided, bitter and schizophrenic that almost nothing can get done (witness the annual, down-to-the-wire wranglings over federal budgets and debut ceilings).

President Obama’s opponents were so incensed by his entry to the White House (black, articulate, intellectual, liberal – the perfect combination of personal characteristics to inflame neo-conservatives and the religious Right), that they have filibustered, talked down, litigated (often vexatiously) and used every other political tactic possible to render his presidency

impotent. They have succeeded – and brought shame to American politics and to American democracy in the process.

The third major development I have identified may, at first, seem lightweight and trivial when considered alongside the very serious problems mentioned above; it is the super-fast rise of internet social networking sites, as exemplified by Facebook, Twitter, YouTube, etc.

But these sites and mobile messaging services such as Blackberry Messenger are already helping to reshape how people interact all over the world, and to change how societies and communities (communities that are not necessarily nationally based) organise themselves. Because sites like Facebook automate and make effortless communication between and within large groups (a single posting or message can reach a group of thousands within a few seconds – turning it into a broadcast), new ways of organising and communicating are emerging which have the power to create instant pop stars, hit movies or new political movements – just like traditional broadcasting, but more targetted.

The fourth major development since the 2007 edition of this book is the uprising in the Arab world – and this was powerfully facilitated by the rise of social media sites on the internet[1]. The revolutions in Tunisia and Egypt were organised through such social media sites - and the sites also served as news outlets (non-traditional broadcasters). At the time the revolutions began there were about two million Facebook users in Tunisia and five million in Egypt.

Of course, the uprisings in the Arab world were not caused or triggered by social networking sites; demographics lies at the heart of these revolutions. Many repressive Arab autocracies are led (or were led) by aging despots of long tenure, while two-thirds of the population in Northern Africa and the middle east are under 24 years of age. Many people have seen revolution coming, but no one predicted the 'domino effect' as it is now being played out in the Arab world.

A new democratic state in now emerging in Libya and the national uprising that led to it was also organised and broadcast on Facebook and Twitter, with on-the-ground video being posted directly to YouTube – as is the continuing unrest in Syria. And if you think that authoritarian governments can simply 'switch off' national access to the internet and nullify the power of such organisational tools, you will see in the main section of this book that adding a tin can, some copper wire and a few other bits and piece to a 'smart' mobile phone can enable it to connect to the internet wirelessly at very long distance (e.g. across national borders) and with passing satellites that provide internet access. The people can no longer be silenced by authoritarian government decree – they now have their own broadcasting system.

A site that started out linking college students with each other (Facebook), and a site that limits text messages to 140 characters (Twitter), may not seem to have the potential to revolutionise the world, but this is just what is happening as these sites take on the role of broadcasters. And YouTube provides a global platform for the video evidence.

It is already clear that this upwelling of desire to overthrow dictators in the Arab world will be as important to world politics as was the fall of the Berlin Wall and the end of soviet communism and the Cold War. This global movement for democracy and freedom – facilitated by the internet and social media sites – has only just begun. As Lenin once said:

> "Sometimes decades pass and nothing happens; and then sometimes weeks pass and decades happen."

The fifth global development that has occurred in the last four years is another 'event' rather than a new trend; it is the terrible earthquake and tsunami that hit North Eastern Japan in March 2011. Normally events such as earthquakes, tsunamis, great storms, etc., would not feature in any futurist's analysis of future trends (by definition, the effects of such events pass), but the impact of the seismic shocks on the Daiichi nuclear power generation plan at Fukushima caused major safety problems that led to the evacuation of much of Northern Japan and some parts of Tokyo for a while. Even if the safety crisis at the nuclear plan does not prove to have widespread health implications for those who were resident in the region around the plant (and this is far from certain at the time of writing) the impact on the future building and operation of nuclear power plants all around the world may be affected.

In the 2007 edition of this book I wrote that my main objection to nuclear power generation was financial rather than any worries over nuclear safety: no one can really quantify the cost of a unit of electricity generated by

nuclear power (the costs of looking after the hazardous waste continue too long for it to be costed properly).

But since 2007 I have become so alarmed at the increase in global warming, and the back-pedaling by the global community on efforts to tackle the climate crisis, that I was coming to the definite conclusion that, despite the financial costs we would be handing down to future generations, nuclear power generation would have to be an important part of the mix in switching to much cleaner energy.

But now some of the world's democratic communities will be far less likely to endorse the building of new nuclear-powered electricity generating stations – e.g. Germany and Switzerland subsequently renounced all plans to build new nuclear power stations. And governments are already rethinking their plans to extend the life of old reactors currently operating.

The public's reaction against a renaissance of nuclear power is probably illogical – new reactors are totally different in design and are much safer than those that were built 30 or 40 years ago – but I suspect there will be a lingering emotional reaction within the voters of many nations against the idea of building new reactors.

As a result, the switch we must make to cleaner forms of energy generation just got a lot more difficult. Even more money will have to be invested in renewable forms of energy generation such as wind power, solar power, geothermal, tidal power, etc.

But without new nuclear capacity there is a real possibility that parts of the developed world will be facing long periods of power shortages in 20 year's time. That is the legacy of the Fukushima Daiichi plant disaster and it will change our all of our futures.

But despite the five very significant global developments that have occurred in the last four years, most of my conclusions about the likely shape of life in the year 2030 remain unchanged since this book's first publication. Perhaps only the reshaping of the Arab world and the potential that social media communications now offer for undermining authoritarian governments will shape the future differently from the projections I made in 2007.

As always feedback is welcome to ray@rayhammond.com or at www.rayhammond.com

Ray Hammond
London, September 2011.

About the author and the consulting referees.

Ray Hammond
Ray Hammond is a futurist who, for over 30 years, has researched, written, spoken and broadcast about how future trends will affect society and business. He is the author of four futuristic novels, ten non-fiction books and various film, TV and radio dramas. His books have been bestsellers in the USA, UK, France, Spain, Czechoslovakia**,** Poland, Japan and China.

In October 2010 Ray was presented with the Medal of the Italian Chamber of Deputies at the United Nations Pio Manzü International Research Centre in Rimini, Italy for services to futurology.

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I.M. ('Dharme') Dharmadasa is Professor of Electronic Materials & Devices at Sheffield Hallam University, UK. In addition to his research into thin film solar power technologies, Dharme is actively involved in public awareness work on applications of renewable energy in the society. He has also designed a 'Village Power' programme using solar technologies to empower rural communities and to assist in the reduction of poverty.

The Backdrop To The World In 2030

There are seven key drivers of change that will shape the world of 2030. These are:

1. Uneven World Population Explosion And Changing Societal Demographics
2. Climate Change and the Environment
3. The Ongoing Energy Crisis
4. Ever Expanding Globalization
5. Multiple Revolutions in Medical Science
6. Accelerating, Exponential Technology Development
7. The Bottom Billion People (actually, now around 1.8 billion)

Many other factors will shape life and society in the developed and the developing world two decades from now, but these seven are by far the most important drivers of change.

World Population Explosion And Changing Societal Demographics

The year 2011 saw world population rise to over seven billion people. Therefore my first inescapable conclusion is that there are already too many people on the planet. But it is credibly forecast that the world's population will increase by at least 50 per cent before the rate of increase in population growth slows down.

By 2030 there will be over eight billion and by the middle of the century there will be at least nine billion.[2] This is the official 'median' estimate of the United Nations Population Division but many other agencies and organizations believe this estimate is far too conservative. The United Nations itself acknowledges in its alternative 'high variant' projection that it is possible that world population could even double between now and 2050 – a projection that suggests that by as early as 2030 (rather then 2050) there will be nine billion people[3] on the planet.

(In the past the United Nations has proved to be fairly accurate in its long-term population predictions. The prediction it made in 1950 about world population in the year 2000 was very accurate indeed.)

Other factors that will swell the numbers of humans consuming the resources of the planet include philanthropic medical intervention that will begin to eradicate many large scale killer diseases on the African continent and much extended life expectancies in the developed world.[i]

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[i] In the poorest communities large families are an economic and social necessity (to provide cheap labour and to insure against high rates of infant mortality). Despite widespread philanthropic efforts to distribute

This population explosion will present significant problems for every nation in the world. As Dr James Canton, [4] an American futurist who has advised three White House administrations on the future, writes in his book 'The Extreme Future':

> The global management of nine billion people who demand health, food, work, shelter and security will be the most daunting challenge any civilization has ever faced…
>
> Feeding nine billion people in 2050 with an environment that cannot sustain six billion today is a challenge of great proportions. We most certainly need to change our perspective about the environment in order to best prepare for the changes in climate that are coming. We probably cannot feed the planet without advanced, accelerated agriculture to head off mass starvation in the future. [5]

According to the World Wildlife Fund, [6] 1986 marked the year that the number of humans alive reached Earth's natural carrying capacity. The organization goes on to add that by 2050, if world population reaches nine billion, we will require nearly two planet's worth of resources to support ourselves. The inevitable results, they say, will be fished out oceans, overgrazed pasture, destroyed forests, heavily polluted oceans and an overheated atmosphere.

But such conclusions are arrived at by linear projections. Modern futurologists know that such projections are unsafe. In the early 1960s and 1970s it was gloomily forecast[7] that the world would be starving by the year 2000.[ii] A simple calculation of projected population growth and the world's

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plastic and latex condoms (to protect against disease) such provision is unlikely to slow climbing birthrates in the foreseeable future.

[ii] A fear fuelled in particular by 'The Population Bomb', a book by Paul Ehrlich of Stanford University which was published in 1968. This book suggested that overpopulation would soon result in the world running out of food, oil and other resources. It proved spectacularly wrong, but it acted as a clarion call for the modern environmental movement.

annual agricultural output led to this conclusion. But the doomsayers hadn't considered the potential of the 'Green Revolution'[8] that was taking place even as they made their prognostications. From the 1950s onwards improved fertilizers, crop breeding programmes and factory methods of farming boosted agricultural output by several hundred per cent. There was no overall shortage of food produced in the year 2000, even if many people in the world went hungry.

By 2030 food production will have been revolutionized yet again. The genetic modification of crops and livestock will produce seeds that can grow in the harshest of conditions[9] (despite worries over the proprietorial commercialization of agriculture – see the section 'Climate Change and the Environment') and meat that can be grown on its own in factories, [10] without a host animal. Covering films and irrigation systems are already allowing European farmers to produce multiple crops in a single season and these techniques will be widely exported to the developing world to boost food production.

Indeed, for reasons of climate change we cannot go on deforesting our planet to grow more and more crops and rear more and more cattle. We have already exceeded the percentage of forested land that should be put to agriculture and the planet can yield up no more of its trees. As Professor James Lovelock,[11] one of the first scientists to raise the issue of climate change and man who popularized the concept of the 'Gaia Hypothesis'[12] (the Earth as an organism), [iii] writes in 'The Revenge of Gaia':

[iii] The first scientist to think of the Earth as a 'living organism' was Russian-born Vladimir Vernadsky who laid out the theory in his 1926 book, 'Biosfera'

> I like to speculate on the possibility that we could synthesize all the food needed by eight billion people, and thereby abandon agriculture…
>
> The chemicals for food synthesis would come directly from the air, or more conveniently from carbon compounds sequestered from power station effluent, and all that we would need in addition would be water and trace elements.[13]

Another factor that will have a major impact on food production methods is climate change, but the impact of this is harder to predict and will vary from region to region. Suffice to say that technological advances in food production methods will continue to have the potential to feed the Earth's enormously expanded population even if, in some of the world's poorest regions, poverty, corruption, bad politics and conflict (and, in some areas, acute climate change) will continue to cause widespread famine. Drinking water, on the other hand, is often forecast to be in very short supply in some parts of the world (fresh water accounts for only 2.5 per cent[14] of all the water in the world and most of that is frozen). Today, over one billion people worldwide do not have access to clean drinking water. Disease resulting from contaminated water leads to 1.8 million deaths every year and can account for 80 per cent of all illnesses in developing countries.[15]

The pressures on water are well illustrated by the following report published by US Nation & World Report:

> Over the course of the past 40 years, north Africa's Lake Chad has shriveled to one tenth its earlier size, beset by decades of drought and agricultural irrigation that have sucked water from the rivers that feed it – even as the number of people whose lives depend on its existence has grown. In 1990, the Lake Chad basin supported about 26 million people; by 2004 the total was 37.2 million. In the next 15 years, experts predict, the incredible shrinking lake and its tapped rivers will need to support 55 million.

> The population growth has coincided with a 25 percent decrease in rainfall, with global warming very likely a factor. As oceans store more heat, the temperature difference between water and land dissipates, sapping power from rainmaking monsoons. At the same time, desperate people are overusing wells.
>
> Lake Chad, with its confluence of troubles, is emblematic of a burgeoning water crisis around the world. While the western United States faces serious water problems, American money and know-how can at least soften the blow. Not so elsewhere. Worldwide, 1.1 billion people lack clean water, 2.6 billion people go without sanitation, and 1.8 million children die every year because of one or the other, or both. By 2025, the United Nations predicts 3 billion people will be scrambling for clean water. [16]

The United Nations further predicts[17] that by the middle of this century between two billion and seven billion people will be faced with water scarcity and this is likely to cause serious political unrest and conflict.[iv]

Recently the Swiss bank Credit Suisse published a report called 'Water'. In the report the insurance firm pointed out:

> - Water demand is doubling every 20 years – more than twice the rate of population growth.
>
> - Water utilization rates have doubled in the past 45 years.
>
> - Seventy per cent of global demand for water is agriculture, 22 per cent industry and eight per cent domestic.
>
> - The absolute quantity of water supply is the same now as it was 10,000 years ago.
>
> - Asia is home to 700 million people who drink unsafe water and two billion who do not have adequate sanitation.
>
> - American water consumption is 70 per cent greater than European consumption.

[iviv] However, some serious long-term efforts are being mounted to address the problem of future water shortage and hopes are high for a new nano-plastic membrane that is capable of converting saltwater into freshwater.

> - An estimated third of the world's population currently lives in water-stressed or water-scarce countries.
>
> - In most countries, the price of water fails to reflect adequately the cost of supply.
>
> - An estimated 85 per cent of domestic water usage ends up wasted.
>
> - By 2025, 18 countries will have water demand in excess of supply and 58 countries (or 64 per cent of the population) will be under significant pressure.[18]

But the really big question of whether or not the world can gear up to feed over nine billion people seems to have been answered with a 'yes'. In a special report on the population explosion published in early 2011, The Economist predicted:

> But though not easy, it should be perfectly possible to feed 9 billion people by 2050. A start has been made to boosting yields and reducing harvest losses in countries that lag behind, notably in Africa. The "livestock revolution" can be furthered by genetic improvements. Above all, advances in plant genetics should enable breeders to push up the annual growth in yields of staple crops from 0.5-1.0% to 1.5%—which would produce enough for everyone. By 2050 the growth in the world's population will have slowed almost to zero, changes in food demand will come mainly from changing diets and the biggest food-supply problem will be dealing with the effects of climate change[19].

Societal Demography

The age make-up of the world's population is changing dramatically and the effects of this will be very apparent by the year 2030.

In 2006, nearly 500 million people worldwide were 65 or older. By 2030, according to a US government report, [20] the total is projected to double to one billion – one in every eight people on the planet. The fastest increases in

those 65 and older are occurring in developing countries, which will see a jump in those populations of 140 per cent by 2030.

As the website Transgenerational.org points out:

- For the first time in history, people aged 65 and over will soon outnumber children under the age of 5.
- Throughout the world today, there are more people aged 65 and older than the entire populations of Russia, Japan, France, Germany and Australia—combined.
- By 2030, 55 countries are expected to see their 65 and older populations at least 20 percent of their total.
- By 2040, the global population is projected to number 1.3 billion older people—accounting for 14 percent of the total.
- By 2050, the U.N. estimates that the proportion of the world's population age 65 and over will more than double, from 7.6% today to 16.2%[21].

But although developing countries will see the greatest percentage increase in their elderly populations it is the European nations that are predicted to suffer most economic pressures from low birthrates and ageing populations[22].

However, it is unsafe to assume that all the ageing European societies of 2030 will have trouble supporting their elderly populations. Three changes to our societies are likely to prevent this. The first is that people will work longer, the second is that there will continue to be massive waves of immigration of young people from the less developed world into the most developed countries and the third is that accelerating technological innovation will increase wealth rapidly in the most highly developed societies (although some of this new wealth is likely to be eaten up in efforts to tackle and adapt to climate change).

On the subject of working longer, most European countries will have raised the official retirement age[23] by at least a year or two by 2030 (Italy has already raised the retirement age for its citizens by three years starting in 2015[24]) and improved fitness brought about by preventive medicine and improved health care will render the workforce capable of working (happily, even eagerly) for longer. Indeed health quality and life expectancy will be so greatly increased[25] by 2030 that retirement at 60 or 65 will seem pointless. It may be the point at which people merely change career.

On immigration, figures from the UN's population division[26] predict a global upheaval without parallel in human history over the next four decades. At least 2.2 million migrants from poor nations will arrive in the rich world every year from now until 2050, according to the United Nations. This means that a total of 55 million new immigrants will have settled in developed nations over the next twenty years.

In Europe, the UN predicted that Britain, France and Spain would receive the most new immigrants and the Swiss population is expected to reach the eight million[27] mark by 2030, an increase of 9 per cent, mainly as a result of immigration. On the other hand the UN predicts that Germany, Italy, Poland and Russia will see their populations drop because of low birth rates, lower immigration by foreign nationals and increasing emigration by their own citizens. Bulgaria's population will fall by 35 per cent by 2050. Ukraine's will plummet by 33 per cent, Russia's by one quarter and Poland's by one fifth. There will be 10 per cent fewer Germans and 7 per cent fewer Italians by the middle of the century.

But the flow of migrants across borders will dramatically increase the populations of most other developed countries, even though Europe's population will grow more slowly than the USA.

In 2010, the population of Western Europe was larger than that of the United States by nearly 100 million people; by 2030, it is expected to be greater by just 35 million. [28] Whereas the US population is anticipated to grow by over 65 million during that period (implying a robust rate of increase of about 0.8 per cent per year), western Europe's population is expected to remain virtually stagnant (growing by less than one per cent over the entire 25-year period).

It is clear that by 2030 the majority of developed nations with aging populations (including the United States) will have long since flung open their borders and greeted with enthusiasm young and ambitious immigrants. Those that fail to do so will risk becoming economic also-rans.

The one exception may be Japan, a nation with a rapidly ageing population, but one that has long cherished its cultural isolation. Rather than open its borders to immigration, Japan is investing heavily in developing robots that can take care of its elderly[29] and produce new wealth within society. I have no doubt that by 2030 robots will indeed be producing massive wealth, and that they will be able to take care of the elderly. But it remains to be seen what sort of future awaits a nation made up of mainly old people being cared for by a population of robots.

Climate Change

The global financial crisis of 2008 and the resulting sovereign debt crises of 2010/2011 have pushed the issue of climate change down the world's political agenda and down the agenda of the media. As a result important opportunities to begin large-scale ameliorative efforts to halt the rise in atmospheric temperatures have been missed.

The all-important meeting of political leaders in Copenhagen in December 2009, that was touted as being the time and the place where a real stand against global warming would be made, turned into a farcical display of impotence. Schizophrenic America, politically divided by the election of Barrack Obama as never before in recent history, denied the new president the legislative scope at home that would be necessary for the United States to lead the world in the fight against global warming. The meeting in Cancun a year later also made no progress. As I write (in late 2011) the outlook for concerted global progress in tackling the problem looks bleak – and President Obama's attempt to curb domestic greenhouse gas emissions is running into extreme partisan opposition.

The issue of climate change is so serious that I think we should abandon the description 'climate change' (although it is scientifically accurate) and I propose we should re-name this atmospheric malady 'Climate Disease' or 'Climate Catastrophe' to underline the seriousness of the problem.

The changes to our climate are palpable for all to feel and increasingly easy for scientists to measure. The evidence[30] that such an abrupt change is anthropogenic (caused by humankind) is overwhelming but a few die-hard skeptics[31] still insist it might be a natural phenomenon. However, the argument about whether humankind is responsible for these changes is irrelevant. It is clear that an abrupt alteration to the planet's normal weather patterns is occurring and this poses a great danger for many of our societies. Over the last 100 years the average global surface temperature has risen by about 0.74C. This seemingly small rise has already had a significant effect on our planet

If storms worsen, sea levels rise, flooding increases, droughts lengthen and heat waves intensify, millions of humans will be killed, millions will be displaced and society will begin to break down. There will be refugees at all of our doors. We may even become refugees ourselves.

As New Scientist reported in Spring 2011:

> It was a monstrous monsoon. Over just a few days in late July last year, more than 300 millimetres of rain fell on northern Pakistan. As the water swept down the river Indus, it killed close to 2000 people and affected 20 million more.
>
> Pakistan was not the only place to suffer. Australia, China, Thailand, Brazil, the Balkans, Bangladesh, Indonesia, Colombia, the Philippines, Sri Lanka and Tennessee all experienced devastating floods in the past year. What's more, there were unusually heavy snowfalls in many regions, severely disrupting transport systems. Globally, 2010 was the wettest year ever recorded[32].

We do know that so-called greenhouse gases[33] trap heat in our atmosphere – principally carbon dioxide, methane and nitrous oxide – and, leaving aside

the debate as to the root cause of climate change, it is our clear duty now to cut down sharply on the deliberate emission of any gases which increase heat retention.

Because there are so many variables in the science of climate change, and because human response to the problem is a matter of social and political will, it is impossible for any futurologist to predict how the climate itself will be behaving beyond 2030. However, it is possible to predict that climate change will still be one of the most pressing problems facing humankind in the next few decades (no matter if the world's political will to tackle the problem is revived and no matter how efficacious future global political response to the issue becomes over the next twenty years) because there is a time delay built in to our atmosphere's responses to heating.

In his influential book 'The Weather Makers', environmentalist and zoologist Tim Flannery writes:

> As our planet heats up it takes the surface layers of the oceans about three decades to absorb heat from the atmosphere, and a thousand years or more for this heat to reach the ocean depths. This means that our oceans are currently reacting to the gases we pumped into the atmosphere in the 1970s.[34]

And that means that the heat-trapping gases we're pumping out now in the second decade of the 21st Century will be the heat that is released from the oceans after the year 2030, heated water that will become the fuel for future hurricanes and tornadoes. And that quantity of heat will be considerable: since the industrial revolution began in 1751 roughly 305 billion tons of carbon have been released to the atmosphere from the consumption of fossil

fuels and cement production. Half of these CO_2 emissions have occurred since the mid 1970s.[35]

As a result of the oceans storing the heat trapped by our present greenhouse gas emissions, in twenty years' time hurricanes of similar or even greater strength to Hurricane Katrina which devastated New Orleans in 2005 will have become far more frequent events,[36] even if global efforts over the next two decades to reduce future carbon emissions have been heroic. The weather in 2030 will be extreme.

The Looming Energy Crisis

It's obvious if you think about it. We're running out of fossil fuels. Even as I write these words new technologies are being announced that can further improve extraction capabilities[37] to mine fossil fuels, pushing back the point at which fossil fuels will be priced out of the energy market. But all such announcements miss the point. It is clear, not least for the very pressing reasons of climate disease, that we have to find new and clean methods of providing our societies with the vital energy they need. And this must be done even as world population balloons and energy demands soar.

Yet the clean energy we need is all around us, in the sun, the wind, the waves and the rocks. It's just that we greedy, lazy, avaricious humans haven't had to go to the bother of harnessing it: until now.

Mandatory reductions to our energy usage is not the answer to the looming energy crisis (although conservation and efficiency must be vastly

improved). Human evolution spurs us to seek continual growth, both personally and collectively, and any concerted legislative attempt to restrict growth or economic activity would produce great social unrest and alarming macro-economic consequences.

The solution to the energy crisis is complex because the problem is complex. Humans have consumed external energy since the first camp fire was lit (and there is a growing body of scientific thought that suggests it was the harnessing of fire and the cooking of food that produced the evolutionary spurt which led to the emergence of homo sapiens[38]). And now that there are to be between nine and twelve billion humans on the planet by mid-century, all of them seeking better standards of living, there's going to be a huge and rapidly growing desire for more and more energy.

I stood in the blazing sunshine of a hot summer's day in Sydney recently contemplating the fact that, per capita, Australians are responsible for releasing more carbon dioxide into the world's atmosphere[39] than any other nation (even the Americans). The reason is simple to understand; Australia has vast, easily mined coal reserves and this dirty fuel is used to produce 85 per cent of the nation's electricity. [40]

As I spent an hour in Sydney's beautiful botanical gardens the solar energy beaming down on me was so fierce that my skin was burned, yet I saw not a single solar panel in use in the city. And below my feet I knew that there was enough accessible geothermal energy to provide all of Australia's power generation needs[41] for the rest of the 21st Century.

The solution to the energy crisis (and to the ever worsening effects of climate change) is literally all around us, in the wind, in the waves, in hot rocks and in the sun's heat. It will be difficult and expensive to harness natural, clean energy sources and it will be economically painful to wind down our investments in fossil fuel energy extraction. But it must be done, and quickly.

Globalization

The term 'globalization' has many meanings and evokes many different emotions. At one extreme the word is used to mean 'global economic exploitation of the poor by the rich' and, at the other, 'a global movement to reduce poverty and promote peace'. Both extreme forms of globalization are being pursued today, along with many more moderate examples and the massive trend towards the internationalization of trade will be a major driver of the changes we will experience between now and 2030.

Globalization[42] in essence means unfettered international trade, although the world still has a long way to go before all barriers to trade are removed. In principal, trade – and especially international trade – is a good thing in which all parties to the deal increase their wealth. Increasing global wealth is a noble aim and little is more successful in guaranteeing peace than improving prosperity. The financial benefits of globalization are explained in an economic theory called 'comparative advantage'.[43]

European nations pioneered a colonial form of globalization in the 18th and 19th centuries as they expanded their empires and traded goods all

around the world, but since then free trade has suffered many setbacks from outbreaks of nationalism, protectionism, world wars (and a complete retreat from globalization between the world wars) and over fifty years of global ideological polarization between capitalism and communism.

Following the collapse of the Soviet Union and the end of the Cold War the stage was ready once again for trade on a truly global scale to resume. This time, however long-distance trade was facilitated by the arrival of the internet, low-cost communications technology and (acknowledging the legitimate concerns over aviation's impact on climate change) low-cost air travel.

The most dramatic, and most obvious, example of the impact of globalization followed the admission of China into the World Trade Organization in 2001 when many international trade tariffs were lifted. As a direct result tens of millions of Chinese citizens have been lifted out of poverty[44] and in 2011 China overtook Japan to become the world's second largest economy, behind the United States.

The effect of WTO membership has been to bind China more tightly into existing and highly sophisticated pan-Asian production networks, a task greatly facilitated by the internet. Everybody in the region has benefited, [45] even rich Japan, which in 2002-03 was pulled out of a decade and a half's slump by Chinese demand for top-notch components and capital goods.

South-East Asia has got a further boost: rich in resources, including rubber, crude oil, palm oil and natural gas, it looks likely to profit from China's appetite for raw materials and energy for a long time to come. Now

China's economy is growing by at least seven per cent each year, a trend which is forecast to continue for the next fifteen years.[46] By 2030 China's economy is expected to be the largest,[47] in the world.

In February 2011 the prestigious Brookings Institute of America produced a report which stated that nearly half a billion people have been lifted out of absolute poverty by the globalization that has occurred over the last 20 years[48]. The report goes on to suggest that by 2015, we will not only have halved the global poverty rate, but will have halved it again to under 10 percent, or less than 600 million people, with India and China responsible for three-quarters of the reduction in the world's poor expected between 2005 and 2015.

But today 'globalization' seems to be regarded by many people as the rape of poor ethnic cultures by the rich countries of the developed world – witness the mobs of anti-globalization protestors[49] who turn up at most G8 meetings.

To critics, globalization is seen as the 'McDonald's-ization' and 'Disneyfication' of nations that have been softened up to welcome such a cultural and economic invasion by massive imports of American television shows and films. But the renowned veteran American futurist John Naisbitt[50] (author of the best-selling 1982 book 'Megatrends'[51]) rejects the book 'Mind Set! Reset Your Thinking And See The Future' he observes:

> The question is: 'Does globalization mean Americanization?' My short answer is no. In measuring globalization, we can count telephone calls, currency flows, trade sums, and so on, but the spread of culture and ideas cannot be so easily measured. Embedded in the present is the

> unrecognized paradox that culturally, America itself is changing more dramatically than America is changing the world. Immigration is reshaping America more profoundly that America's influence around the world. In the United States there are more Chinese restaurants than there are McDonald's.[52]

However, another world-famous American futurist, Jeremy Rifkin[53] – author of the bestselling books 'The End of Work', [54] 'The Biotech Century'[55] and 'The Age of Access'[56] – sees both sides of the argument. He writes in his book 'The Hydrogen Economy':

> Globalization is the defining dynamic of our time. Proponents look to it as the next great economic advance for humanity and as a way to improve the lives of people everywhere. Its critics view it as the ultimate example of corporate dominance over the affairs of society and as a means to deepen the gap between the haves and have-nots. Transnational corporations, with the help of the G7 nations, are lobbying to change government regulations and statutes that, they argue, restrict freedom of trade. Anti-globalists are taking to the street in greater numbers to protest what they contend is the systematic gutting of environmental and labour standards designed to protect the Earth's ecological and human communities from corporate rapacity. [57]

Globalization is also seen as an excuse for multinational corporations to use dirt-cheap labour in the developing world to sell ever cheaper products (yet still profitable products) to greedy consumers in rich western societies.

But on the other hand, offshoring, outsourcing, free capital flows and free international trade (which is a less provocative way of describing the process) have the potential, if pursued fairly and in a sustainable manner, to both reduce poverty in the poorest nations and to bring benefits to consumers in the rich world.

The World Bank claims[58] that globalization could spur faster growth in average incomes in the next twenty years than occurred during the period

1980-2005, with developing countries playing a central role. However, the Bank warns, unless managed carefully, it could be accompanied by growing income inequality and potentially severe environmental pressures.

Driven by globalization from 1974 onwards, exports have doubled, as a proportion of world economic output, to over 25 per cent, and, based on existing trends, will rise to 34 per cent by 2030.

By 2030 the world's richest nations will either be pursuing ethical, sustainable globalization – by which I mean fair trade with proper concern for those with whom we trade and the environment in which we trade – or we will be manning the barricades against those who we have dispossessed.

As James Canton puts it in 'The Extreme Future':

> In its crudest sense, globalization is either going to be the most successful revolution to accelerate global democracy, free trade, and open markets, or it will victimize the poor nations of the world… This is perhaps the greatest challenge facing our civilization today. People without a future are the most dangerous people in the world. They will do anything to get a future – or to destroy those who they believe are robbing them of that future. [59]

The Bottom 1.8 Billion People

But even as globalization is starting to lift billions of people out of abject poverty there are approximately 1.8 billion people trapped in about fifty-eight nation states which are experiencing only minute growth, no growth at all, or actual economic shrinkage.

The people in these 'bottom states' don't have access to global markets (and even if they did get such access, they would have little to sell except natural resources).

Most, but not all, of these countries are in sub-Saharan Africa and, typically, their societies have reached a stage of development that is the equivalent to where the societies of Europe were between the 8th and 14th century A.D. These societies are so poor that the people are constantly fighting amongst themselves for what little wealth they possess (as European societies used to do). These societies suffer from plagues and famine, are largely illiterate, have only the most rudimentary healthcare and, because of chronic instability, they attract no foreign investment capital. Indeed, what little domestic capital exists or is generated is almost immediately exported to overseas bank accounts in the rich countries for fear of the same political instability. [60]

The situation is so serious that Robert Gates, Defense Secretary of the U.S.A under both the Bush W. and Obama administrations, says 'Fractured or failing states are the main security challenge of our time'.

Massive amounts of western aid, both financial and in kind, have been given to the countries which are home to the bottom billion – no less than $2.3 trillion, according to William Easterly, [61] Professor of Economics at New York University – but it has made very little difference to the lives or ordinary people in the bottom billion.

The reason our aid has helped so little is that the problem is so great: many of the societies to which we gave our cash were so poor that it was

immediately grabbed and embezzled by all who had any power at all – presidents, dictators, ministers, bank managers, customs officials, diplomats, contractors, even shippers.[62] Many such embezzlers may well have had extended families living in poverty and to put the general good of society above such personal considerations would require the conscience of a saint.

Economist Professor Paul Collier, [63] Director for the Study of African Economics at Oxford University writes in his best-selling book 'The Bottom Billion':

> All societies used to be poor. Most are now lifting out of it; why are others stuck? The answer is traps. Poverty is not intrinsically a trap, otherwise we would all still be poor. Think, for a moment, of development as chutes and ladders. In the modern world of globalization there are some fabulous ladders; most societies are using them. But there are also some chutes, and some societies have hit them. The countries at the bottom are an unlucky minority, but they are stuck.[64]

In this survey of what the world may be like in the year 2030 why should it matter so much to us in the developed world that a billion people (and, potentially, many more by 2030) will be stuck in abject poverty? There are two reasons; the first is the enormous financial cost to the developed world that failing and fighting nations inflict, the second is the almost certainty that such countries will increasingly exact their revenge of us for their abject poverty through international terrorism. Think Somalia, think piracy and kidnapping and the misery the peoples of this failed state are inflicting on the world.

Globalization must now be extended to specifically include the bottom billions, otherwise their vengeance on the rich world will become a seventh major factor that will shape our future – and for the worse.

Accelerating, Exponential Technological Development

There will be more technological change in the next two decades than occurred throughout the whole of the last century. And that was the century that produced aeroplanes, cars, chemicals, plastics, nuclear power, space vehicles, television, the computer, the internet and mobile phones.

The reason I forecast such extreme change ahead is that the speed of technology development is itself accelerating. The key to understanding why this is occurring lies in realising that, a) technology development is itself an extension of human evolution and, b) the speed of technological development is the direct product of the rapidly increasing speed and richness of information flows around the world.

The noted American futurist and inventor Ray Kurzweil[65] has pointed out that since humans first began to extend their biological powers by inventing technology, technological innovation has itself been accelerating at an exponential rate. He writes:

> An analysis of the history of technology shows that technological change is exponential, contrary to the common-sense 'intuitive linear' view. So we won't experience 100 years of progress in the 21st century – it will be more like 20,000 years of progress (at today's rate). The 'returns,' such as chip speed and cost-effectiveness, also increase exponentially. There's even exponential growth in the rate of exponential growth. Within a few decades, machine intelligence will surpass human intelligence, leading to The Singularity – technological change so rapid and profound it represents a rupture in the fabric of human history. [66]

Ray Kurzweil's reference to 'The Singularity'[67] in the above paragraph prompts me to explain the reason that I decided to fix the focus point of this book almost twenty years ahead and not fifty years hence or some other point further into the distant future.

Like Ray Kurzweil, I too am convinced (and have been so for decades) that we are rapidly approaching the point at which machine intelligence will reach a point of equality with human intelligence (which does not mean that computers will be 'as clever' as humans – it will be a different sort of capability). Most futurists estimate that this seemingly disturbing phenomenon will occur sometime during the period between 2035 and 2045 and soon after this milestone is reached human life and society will begin to change in ways that are impossible to imagine using human insight alone.

Within a year or two of machines achieving human-level capabilities, exponential technological development means that machines will have the potential to become twice as capable as humans. A year or so later they will be four times as capable, then eight times as capable and so on. Soon afterwards their capabilities will be beyond any human form of measurement and beyond human understanding.

As I shall discuss in my later section on 'Accelerating, Exponential Technology Development', this is not necessarily the alarming prospect that it might seem, but it is the principal reason that current futurology is unable to peer much further ahead than the fourth decade of the 21st Century. After that the future will become alien, unrecognisable and indescribable to present-day human audiences.

I regard the phenomenon of accelerating technological development as the 'joker in the pack' or a 'wild card' when it comes to considering future trends. During the next twenty years it is possible that presently unforeseeable 'wild card' technologies will be developed that will solve the world's demand for clean energy and, perhaps, even provide some degree of control over the world's climate. It might even solve the drinking water shortage. I shall return to these speculations in the relevant sections.

Radical Developments In Medical Science

While machines may be on what appears to be the verge of usurping our species on this planet, we humans will not be standing still. In fact we will be altering what it means to be human, and in some very dramatic ways.

Because humans often lack a language for the technological future I have created a portmanteau phrase – 'prevent-extend medicine' – to describe a new form of medicine that will emerge over the next twenty years. Instead of attempting to provide cures for existing disease and ailments, the next medical revolution will produce a new discipline in the rich world that will focus on personalized medicine that will prevent illness and increase human longevity very dramatically.

The human genome was first sequenced[68] in 2001 and this provided pharmaceutical companies, medical researchers and academics with a map of what computer scientists would call 'human source code'. In other words, the sequencing laid bare all the component genes that go to make up

a human being. The problem is that we are only now beginning to identify which genes do what in human biology and, as researchers are discovering to their concern, how combinations of seemingly separate genes work together to cause a particular effect.

Although a daunting task, some progress in gene identification is being made. Biologists at Harvard recently identified the gene responsible for triggering tanning[69] when skin is exposed to ultraviolet light. It turns out to be a well-known tumour suppressor called *p53*, often dubbed the 'guardian of the genome'.

Such knowledge may be put to use in both trivial and critical applications. A tanning lotion may one day be produced which turns on the *p53* gene to produce a natural tan within the skin without the user having to be exposed to the harmful effects of ultra-violet radiation from the sun. A more serious use might be to stimulate the body's *p53* genes to attack skin cancer.

As New Scientist reported:

> It's not quite the elixir of life, but researchers may have found a way of keeping us younger for longer. In mice at least, increasing the production of two proteins called p53 and Arf enabled more of the animals to survive to old age while showing fewer signs of ageing.
>
> Since its discovery in 1979, p53 has been a key therapeutic target for cancer research. When activated, it encourages damaged cancer cells to commit suicide - a process called apoptosis.[70]

News of new gene identification now seems to increase daily. Key genes for fighting HIV-Aids[71] have been identified as has a gene that causes a particularly severe form of catatonic schizophrenia.[72] Researchers led by

University of Cincinnati scientists have located a narrow region of genes that can sharply increase a person's risk of developing lung cancer[73] – one of the world's worst killers - and researchers in Montreal recently discovered a gene that seems to inhibit memory retention[74] (which, one day, may lead to a treatment for Alzheimer's disease).

Other disease-related genes identified include those for motor neuron disease, Type 2 diabetes, a gene that appears to inhibit breast cancer, one that causes stomach cancer, a gene that causes deafness and many more. We are starting to understand the buildings blocks of human biology – but it is a slow and complicated process.

Over the next two decades the 'master map' of the human gene pool will be completed to a large extent and, as computer power rapidly increases, it will become possible to sequence the genomic map of each individual patient (at least, of those patients lucky enough to be living in the developed world).

Since the 2007 edition of this book was published I have had all of the important parts of my own genome decoded – but more about that and the implications of such personal DNA profiling in the later section of this book that looks at the future for human longevity.

In 'Extreme Future,' James Canton describes the coming medical revolution in the following way:

> Speculation about disease and treatment will give way to a more precise, predictive and health-enhancing type of medicine: Longevity Medicine. Medicine that has, at its core, an ability to peer into the genomic map of a

> specific individual, from birth to death. Doctors will have an unparalleled diagnostic tool: a person's own DNA. The next stage will include engineered disease prevention, health promotion and life extension.[75]

In addition to such a powerful approach to diagnostics, gene therapy[76] will harness the power of gene identification to produce new drugs and treatments many times more effective than present therapies.

Stem cell research[77] is another exciting new development that promises to revolutionize medicine. A stem cell is basic embryonic human cell which has the ability to grow into almost any kind of cell. A number of stem cell therapies already exist, particularly bone marrow transplants[78] that are used to treat leukaemia.[79] In the future, medical researchers anticipate being able to use technologies derived from stem cell research to treat a wider variety of diseases including forms of cancer,[80] Parkinson's disease,[81] spinal cord injuries,[82] and muscle[83] damage, amongst a number of other impairments and conditions.

In the near future stem cell medicine even promises to grow new bone and tissue for human use that is based on the patient's own DNA. There is good reason to believe that stem cells may allow us to repair and regrow damaged organs[84] and, eventually, to grow 'replacement organs' which would be at no risk of rejection from our immune systems. Replacement human bladders[85] have already been grown and transplanted into humans using stem cell techniques. Recently heart tissue was grown from stem cells[86] suggesting that within five years whole replacement hearts could be grown and scientists have recently succeeded in producing pancreatic cells[87] from stem cells that produce insulin, holding out the hope that diabetes might one day be curable by the growth of a new pancreas. By 2040 such organ

regeneration will be routine and almost all other organs will also be grown from stem cells. We will have our 'backup' parts.

From this discussion of personal DNA mapping, gene therapy drugs and stem cell research you will begin to see why I have contracted and combined the words preventive and longevity to produce my new phrase, 'prevent-extend.'

Writing in 2006, James Canton also observed:

> In the decades to come, medicine will be revolutionized. The convergence of pharma, biotech, and nanotech industries will form the biggest global marketplace with one underlying theme: life extension for sale.
>
> Botox today will lead to gene-replacement therapy tomorrow. Face-lifts today, nano-engineering stem cells for babylike, wrinkle-free skin tomorrow. Even memories will be for sale, with superagility and enhanced intelligence thrown in for good measure.[88]

Well, leaving aside Dr Canton's focus on the commercial bonanza that may derive from the new medical revolution (a perspective all too understandable given the USA's ultra-capitalist approach to social healthcare), I agree with his conclusions. It seems to me that within the period covered by this report, those of us in the rich world will be immeasurably healthier and will live far longer than we currently anticipate.

It is even possible that a child born in the year 2030 may have the option of extending his or her healthy and youthful life almost indefinitely.

Part One

Accelerating, Exponential Technology Development

Consulting Referee:
Professor Allison Druin,[89]
Director, Human-Computer Interaction Laboratory,
University of Maryland, USA

The wealth of the developed world has been generated largely by the invention and application of increasingly sophisticated technology. Some evolutionary psychologists go even further and suggest that it is the invention and use of technology itself that fuelled human development (along with cooking)[90]. It is for this reason that I cover this subject first; technology development will have a significant impact on all of the other subjects discussed in this report.

In a paper called 'Technological Revolutions: Ethics and Policy In The Dark', Dr Nick Bostrom[91] Director of the Future of Humanity Institute, the Faculty of Philosophy at Oxford University, makes clear technology's role in our modern society:

> Technological change is in large part responsible for the evolution of such basic parameters of the human condition as the size of the world

> population, life expectancy, education levels, material standards of living, the nature of work, communication, health care, war, and the effects of human activities on the natural environment. Other aspects of society and our individual lives are also influenced by technology in many direct and indirect ways, including governance, entertainment, human relationships, and our views on morality, cosmology, and human nature. One does not have to embrace any strong form of technological determinism or be a historical materialist to acknowledge that technological capability – through its complex interactions with individuals, institutions, cultures, and the environment – is a key determinant of the ground rules within which the game of human civilization is played out at any given point in time.[92]

In the previous section 'The Backdrop to 2030' I quoted the American futurist Ray Kurzweil's observation that 'the rate of technological development is exponential' and that even this rate is itself speeding up exponentially. Other futurists agree and some go so far as to suggest that accelerating technological change produces accelerating change in society itself.

Rolf Jensen[93] of the Copenhagen Institute for Future Studies[94] describes this in his 1999 book 'The Dream Society':

> The pace of development from one societal type to another is accelerating. The agricultural society originated 10,000 years ago, the industrial society between 200 and 100 years ago, the information-based society 20 years ago. Who knows how many more years the logic and economics of the Information Society will last?[95]

And Alvin Toffler,[96] the world-famous American futurist whose work initially inspired me to go into the field, put it even more bluntly in his best-selling 1970 book, 'Future Shock':

> Western society for the past 300 years has been caught up in a fire storm of change. This storm, far from abating, now appears to be gathering in force.[97]

I agree with these views about constant increase in the velocity of development, both technological and social, and it is for this reason that I have coupled such seemingly tautologous terms as ‘accelerating’ and ‘exponential’ in my heading for this section.

But ‘exponential’ is an easy concept to understand in theory (a doubling every so often – usually over a set, regularly recurring period) but it is hard to appreciate fully how powerful exponential effects are. When a small number doubles the change is almost unnoticeable, when a large number doubles the effect is overwhelming. We are now moving into a period when the effects of exponential technological development will be very noticeable indeed.

Ray Kurzweil also makes the apparently astonishing claim that such exponential development is a natural part of human evolution. In his book ‘The Singularity Is Near’ he writes:

> The future is widely misunderstood. Our forebears expected it to be pretty much like their present, which had been pretty much like their past. Exponential trends did exist one thousand years ago, but they were at that very early stage in which they were so flat and so slow that they looked like no trend at all. As a result, observers’ expectation of an unchanged future was fulfilled. Today, we anticipate continuous technological progress and the social repercussions that follow. But the future will be far more surprising than most people realise, because few observers have truly internalised the implications of the fact that that the rate of change itself is accelerating.
>
> Most long-range forecasts of what is technically feasible in future time periods dramatically underestimate the power of future developments because they are based on what I call the ‘intuitive linear’ view of history rather than the ‘historical exponential’ view.[98]

Kurzweil is a man whose views should be taken seriously. As well as being a noted futurist[99] and best-selling author he is an inventor and engineer, recipient of 12 honorary doctorates, the Lemelson-MIT Prize and the US National Medal of Technology. He was the principal developer of the first omni-font optical character recognition, the first print-to-speech reading machine for the blind, the first CCD flat-bed scanner and the first text-to-speech synthesizer.

His suggestion that exponential technology development is a natural evolutionary trait that has, until recently, been masked from view by slow progress during its early phase, appears to be borne out by an examination of the history of technological progress.

The agricultural revolution began about 12,000 years ago but it took another 6,000 years before humans developed the four virtual technologies that have shaped our modern world; date and time (the clock and the calendar), alphabetic writing, mathematics and the invention of money. (When I describe these technologies as 'virtual' I use the word in its original meaning, not in the computing sense of 'virtual reality.' The English word 'virtual' derives it etymology from the Latin word *virtuālis* which implies something which has an essence or an effect without necessarily having a physical existence.)

The development of physical technologies was even slower in early history. Humankind didn't discover how to produce iron for another 4,000 years (approximately 3,000 years ago, at about the same time as our species learned how to harness wind power for sailing).

The (relatively) stable period of Greek and Roman civilisation ushered in many new military and domestic technologies but, following the collapse of Rome, there followed the Dark Ages – almost 800 years of conflict, pestilence and plague that created a stasis which prevented the invention of any significant new technologies (at least, in Europe).

The ramping up of exponential technological development which has led to today's (seemingly) frenetic pace of innovation began in the 15th Century with the European invention of printing with moveable type. This allowed the knowledge learned by each generation to be stored, replicated inexpensively, distributed and forwarded for the benefit of future generations – and it triggered the Renaissance and, in turn, the Enlightenment.

Now, as the young first began to 'stand on the shoulders of giants', the speed of technological development started to gather pace and it is possible in hindsight to discern its exponential nature (an acceleration fuelled by faster and more rich information flows – the key driver of all accelerating technological development).

In the 16th and 17th centuries the science of navigation (wholly virtual) developed alongside the measurement of time and the shipbuilding technology necessary to build galleons and warships. Telescopes were invented to gaze into the heavens, anatomists peered inside the human body and natural philosophers pondered the physical laws of the universe.

In commerce, the vital virtual invention of ‘the company’ allowed a group of people to create a legal entity independent of any one person, and that laid the foundation of modern capitalism.

By the time civilization reached the 18th Century scientific discovery and technological development were proceeding at such a pace that it triggered the industrial revolution that was to change western society for ever. Workers left rural areas for cities and began to create our modern way of life. Today cities dominate our economies, our nations and our way of life.

In the 19th Century ‘technological invention’ in the sense we understand the phrase today, began to shape history and drive progress. The harnessing of electricity and the subsequent development of the telegraph, the telephone, railroads, the automobile and radio laid the foundations for the most recent century of technological innovation (and technology-mediated war). Information and knowledge flows within society became ever faster.

And here, considering the momentous developments of the Victorian Age, we first notice a difficulty that inhibits our ability to think meaningfully about the future: when developments comes thick and fast we lack a language with which to describe our technological future. And, I suggest, where there is no language, there can be no meaningful thought.

By definition the invention of new technologies produces actions and capabilities for which we have not yet invented words and for which we do not have concepts. We struggle to describe the capabilities of new technology by shoe-horning existing words and concepts together.

For example, when the projector was first invented it was called a ‘magic lantern’ in the English language and the railway locomotive was an ‘iron horse’. The automobile was a ‘horseless carriage’ and the radio was a ‘wireless.’ A refrigerator was an ‘ice box’ and an aeroplane was a ‘flying machine’ – you get my point.

But even though society lacked the language with which to think about and describe new capabilities, technological development continued on its ever quickening exponential curve through the 20th Century – delivering automobiles, television, computers, jet travel, space exploration, plastics, computer networks, the internet and mobile phones to mention just a few 20th Century innovations.

The American futurist John Naisbitt explores the problems that such accelerating development brings to society in his publication, ‘Mind Set! Reset Your Thinking And See The Future’:

> The advances of technology have always resulted in social change. The discovery of fire led to warmth, better food, and the beginning of real community. The wheel, electricity, and the automobile all dramatically changed our social arrangements. The difference today is that the accelerated rate of technological change has been so great that the social accommodation to new has lagged further and further behind. The evolution of technology is now running ahead of cultural evolution, and the gap is increasing.[100]

And in the ‘gap’ between technological evolution and cultural evolution that John Naisbitt describes is a no-man’s land in which we lack even the language to describe the new technologies and the new concepts they bring to our lives.

A good example of our paucity of language for describing new technology is the term ‘mobile phone.’ Nobody has a mobile phone which is just a phone any more. All popular models store information in a database, many models have cameras built in, some are able to play music, others offer GPS tracking systems, some are internet-capable smartphones and at least one model is also a magic lantern.[101]

The phrase ‘mobile phone’ will probably come to seem as quaint as ‘horseless carriage’ once a new, more accurate and all-embracing term for this universal network device gains widespread acceptance.

But whether or not we have got the words with which to describe new technologies and their potential (what they can do and the social, economic and political repercussions they will bring) new inventions, concepts and techniques are flooding out of the world’s laboratories and development centres at an ever increasing pace.

And it is for this reason that I open the main part of this book with a discussion about the type of technologies that may emerge between now and 2030 (and because the implications of this exponential technology development are so extreme) As I mentioned in my introductory ‘Backdrop’ section, new technology is the ‘joker’ in the pack of cards that will shape our future. It has the greatest potential to affect dramatically all of the other ‘key drivers’ of change that I have identified – except, alas, the continuing explosion in the world’s birthrate.

New technologies likely to be developed between now and the year 2030 may even have the potential to offer partial solutions to problems such as climate change and the looming energy deficit. For example in early 2011 The Guardian newspaper reported on 'geoengineering solutions' which may be used in the future to offset the worst effects of climate disease[102]:

> Although large-scale geo-engineering is still at the concept stage, advocates claim that it may eventually become essential if the world wants to avoid the worst effects of climate change. Critics, by contrast, claim that geo-engineering isn't realistic – and may be a distraction from reducing emissions.
>
> The first category of scheme – those designed to remove CO2 from the air – include machines (sometimes called "artificial trees") that pull the gas from the atmosphere using plastic polymers. Other proposals seek to increase the amount of CO2 absorbed by the oceans – for example by adding large quantities of lime to the water.
>
> Other related schemes – sometimes but not always described as geo-engineering – involve harnessing the capacity of trees and plants to absorb CO2 from the air. These include burning large quantities of wood in power plants with carbon-capture technology; making and burying large amounts of charcoal to lock carbon into the soils; and grazing cattle in a way designed to turn grasslands into giant carbon sinks.
>
> In the second category – schemes designed to reduce the amount of sunlight reaching Earth – proposals include firing sulphate aerosols into the stratosphere to reflect sunlight back to space; using unmanned ships to increase above-ocean cloud cover by spraying sea water into the air; painting the world's roofs white to increase reflectivity; and even floating thousands of tiny mirrors in space between Earth and the s

And the New Scientist reported on plans to counteract the effect of global warming by blocking some of the sun's rays from reaching the planet:

> Basically the idea is to apply 'sunscreen' to the whole planet. It's controversial, but recent studies suggest there are ways to deflect just enough of the sunlight reaching the Earth's surface to counteract the warming produced by the greenhouse effect. Global climate models show that blocking just 1.8 per cent of the incident energy in the sun's

> rays would cancel out the warming effects produced by a doubling of greenhouse gases in the atmosphere. That could be crucial, because even the most stringent emissions-control measures being proposed would leave us with a doubling of carbon dioxide by the end of this century, and that would last for at least a century more.[103]

Whether or not new technologies will play a role in mitigating climate change new technologies and techniques seem almost certain to radically enhance human health and longevity and, setting aside potential, unpredictable catastrophes such as global epidemics, natural disasters or massive nuclear war, new technological developments (coupled with globalization) seem certain to drive robust economic growth all around the world. To put it simply, machines are now generating value and wealth for our societies and they will generate more and more wealth as they become rapidly smarter.

Any dissertation on the potential benefits of technological progress always risks the author being accused of hubris, techno-prolepticism and an over optimistic attitude to the future. This is not my standpoint and while many analysts study technologies in isolation, I believe it is important to see them in their social and human contexts. Technology is no panacea, as we shall see in the later sections of this book that deal with 'Climate Change And The Environment' and 'The Future of Energy'.

However, I have been certain for some decades that in creating intelligent machines the human race is in the early stages of creating a successor or companion species to human beings. Many other commentators have reached the same conclusion. Writing in the New Scientist magazine Dr

James Hughes,[104] Executive Director of The Institute for Ethics and Emerging Technologies[105] in Connecticut, observed:

> It seems plausible that with technology we can, in the fairly near future, create (or become) creatures who surpass humans in every intellectual and creative dimension. Events beyond this event—call it the Technological Singularity—are as unimaginable to us as opera is to a flatworm.
>
> The preceding sentence, almost by definition, makes long-term thinking an impractical thing in a Singularity future.[106]

We are, however, able to project a likely pathway towards the point of disjuncture in human evolution that is being called 'The Technological Singularity', even though along the way the ever increasing rate of technological development will produce wrenching and continuous change in all our lives.

We don't have any option but to embrace change, and very rapid change, in the 21st Century and the only successful antidote to the painful symptoms of change that I have discovered is continuous, life-long learning. Keeping up to date is vital to weather the storms produced by high-speed, violent change. As Louis Pasteur remarked; 'Change favours the prepared mind.'

Rolf Jensen of the Copenhagen Institute for Future Studies describes it very simply in 'The Dream Society':

> The past is receding from us at a dizzying speed. The future is heading toward us with increasing velocity. You might say that the future is drawing closer – it is almost becoming part of the present.[107]

At the root of almost all this change is the computer – these days specifically the microprocessor and its associated architectures – which until a few years

ago was doubling in power and speed every two years but which now appears to be developing even faster.

Moore's Law

The most important of all mankind's inventions will turn out to be the computer – and, by extension, computer networks, wired and, increasingly, wireless. As the computer is a universal tool it is of crucial importance to the future of science, medicine, security, business, education and industrial activity. The most dramatic technological change in society is driven by advances in computer power and miniaturisation – for example in drug development, mobile phones and cellular networks, the internet, nanotechnology and brain scanners. In fact, almost all technological development is now wholly dependent on the computer.

In April 1965 Gordon Moore,[108] one of the two founders of the chip maker Intel, saw an article of his published in the American publication *Electronics Magazine.* He wrote:

> The complexity for minimum component costs has increased at a rate of roughly a factor of two per year... Certainly over the short term this rate can be expected to continue, if not to increase. Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least 10 years. That means by 1975, the number of components per integrated circuit for minimum cost will be 65,000. I believe that such a large circuit can be built on a single wafer.[109]

This prediction was proved correct and the phenomenon of computer power continuing to double every two years became so startling that the visionary observation came to be honoured as 'Moore's Law.'[110]

Today, even though ‘Moore’s Law’ is often evoked (usually inaccurately) to describe the high speed of microprocessor and computer development, the concept has become something of a self-fulfilling prediction (more ‘lore’ than ‘law’) and has become a ‘bench-mark’ to which the computer industry works.

Tellingly though, Moore’s law has contracted sharply and microprocessor speeds and densities have for many years been increasing much faster than Gordon Moore predicted in 1965.

Dr Nick Bostrom observed in a 1997 paper on Superintelligent Machines:

> Moore's law states that processor speed doubles every eighteen months. The doubling time used to be two years, but that changed about fifteen years ago. The most recent data points indicate a doubling time as short as twelve months. This would mean that there will be a thousand-fold increase in computational power in ten years. Moore's law is what chip manufacturers rely on when they decide what sort of chip to develop in order to remain competitive.[111]

Also in 1997 noted American futurists Marvin Cetron[112] and Owen Davis[113] wrote in their best-selling book ‘Probable Tomorrows’:

> If the most optimistic computer scientists are correct, tomorrow’s shirt pocket computer could hold a billion bytes (a gigabyte) in its working memory (RAM) – and run at 50 million times the speed of today’s fastest personal computers.[114]

Well, that fourteen year-old prediction was heading in the right direction; my shirt pocket iPhone offers 80 gigabytes rather than a single gigabyte of storage but shirt-pocket processing power has not yet multiplied by a factor of 50 million

So where precisely are we ten years later, and where will we be in terms of processor speed and power in the year 2030?

The answer is that this simplistic question about microprocessor power is no longer adequate or appropriate to judge computer performance.

Computer power no longer relies on the speed of a single processor. Today, computing is a networked activity, both within microprocessor architecture and between independent computers. Microprocessors now have multiple 'cores' (i.e. processing engines) and many multi-core processors are harnessed together in a 'cluster' or 'grid' of computer power which can be 'local' or truly 'global'.

An idea of how powerful multi-core processors are becoming may be gleaned from the following story which appeared in the magazine MIT Technology Review:

> Intel has announced a research project that made geeks jump with glee: the first programmable 'terascale' supercomputer on a chip.
>
> The company demonstrated a single chip with 80 cores, or processors, and showed that these cores could be programmed to crunch numbers at the rate of a trillion operations per second, a measure known as a teraflop. The chip is about the size of a large postage stamp, but it has the same calculation speed as a supercomputer that, in 1996, took up about 2000 square feet and drew about 1,000 times more power.[115]

The important point to note in the extract from the MIT Review story is that dramatic miniaturization occurred in the chip design along with a significant reduction in energy used during operations.

In fact, the amount of energy now demanded by multi-core microprocessors has become a significant issue. The Economist observed:

> The first (energy conservation method) is new 'multi-core' processor chips, in which performance is improved not by increasing clock speed, but by building several processing engines, or 'cores', into each chip—a far more energy-efficient approach. AMD, Intel and Sun now boast of their chips' 'performance per watt' (i.e. work done for each unit of energy), rather than simply emphasising raw performance. Dual-core chips are commonplace, and quad-core chips are spreading too. The switch from dual-core to quad-core over the past 18 months increased performance per watt by a factor of 4.5, says Stephen Smith of Intel.[116]

And in his 2011budget President Obama's included $120 million dollars to develop 'Exascale Computing': Exascale computing systems are said to be capable of 1,000 times the processing power of the fastest computer currently operational, the petascale Chinese Tianhe-1A supercomputer. The previous year President Obama had allocated a mere $24 million for super-computer development.

It is possible that chip developers may hit some sort of physical barrier in the next twenty years as they struggle to make their processors ever faster and ever smaller. They are already working at close to nano-scale[117] and making great use of insulation, even for microprocessor manufacture.[118] However, it is still possible that difficulties of heat dissipation, input and output connects, the barrier of the speed of light itself or problems with the materials in use may bring an end to the supercharged-Moore's law speed of development.

For example, the following comes from a ComputerWorld article published in early 2007:

> Makers of memory chips are looking ahead to a day, not too far off, when technology based on silicon bumps up against the laws of physics and memory can't be made any smaller. That development will have implications for gadgets like MP3 players and digital cameras.
>
> These concerns have major memory makers pouring hundreds of millions of dollars into perfecting the next big technology. The possible alternatives sound like science fiction: M-RAM, P-RAM, molecular memory and carbon nanotubes.[119]

Yet in 1982 I was writing similar qualifications about future chip development as I surveyed what then seemed the breathless pace of microprocessor development. Back then scientists were suggesting that a move to super-cooled computing would be required for development to continue at its present pace (using Josephson Junctions[120]) and many were suggesting that the chip substrate silicon would have to be replaced with more exotic materials such as gallium arsenate.[121]

Today my friends at Intel have been kind enough to share some of their proprietary research projects with me and, without revealing any commercial secrets, I can say that Intel's R&D team does not anticipate hitting any barrier to faster processing in the next couple of decades.

Chip designers are now contemplating the move to nano-scale design, new substrates and even quantum-level computing. According to the academic journal Nature, one new substrate with promise for future processor designs is graphene:

> The latest contender to succeed silicon's throne is graphene. It has been used to make a truly tiny transistor that works at room temperature, offering hope for making faster, smaller electronics devices once silicon reaches its limits (around 2020).
>
> Graphene is a two-dimensional form of carbon, discovered just three

> years ago. It is very thin — just one atom thick — and highly conductive with minimal resistance, which has sent physicists and materials scientists into a frenzy to find applications that exploit these properties.[122]

And in March 2011 I reported in my monthly newsletter 'Glimpses Of The Future' that British researchers have succeeded in finding out how to use grapheme as a transistor[123]:

> Graphene has long been heralded as a key component in the supercomputers of the future, but the problem with making transistors out of the stuff is finding a way to turn them off.
>
> Now however, a new type of design suggests that simply creating 'U' bends in graphene could do the trick as has been demonstrated by scientists at the Nano Research Group at the University of Southampton, U.K.
>
> Graphene is the thinnest material known, made up of sheets of carbon arranged in a honeycomb structure just a single atom thick. This structure allows electrons to pass through it faster than most other materials, making it an ideal candidate from which to make electronic devices like transistors.

I am of the opinion that no insurmountable physical barrier to ever-accelerating microprocessor development lies ahead in the foreseeable future. It is clear that a move to nano-scale fabrication will be needed and new materials may very well be required but I have no doubt that in a two decade's time commentators will still be wondering whether there is any end in sight for the exponentially accelerating development of microprocessors (or will they then be called nanoprocessors?).

In the end, because the exponential rate of technology development is, itself, increasing exponentially it is almost impossible the estimate precisely how much more powerful and more capable the computers of 2030 will be.

There are, however, some well qualified experts prepared to stick their necks out and make firm predictions about the likely speed and power of computers and their networks in the year 2030. Dr. Paul D. Tinari,[124] Director of the Pacific Institute for Advanced Study (and formerly a professor of future studies at San Francisco University) writes:

> According to Moore's Law, computer power doubles every 18 months, meaning that computers will be about 500,000 times more powerful by 2030. Furthermore, according to Nielsen's Law of Internet bandwidth,[125] connectivity to the home grows by 50 per cent per year; therefore by 2030, people will have about 100,000 times more bandwidth than today. By that year, chances are you will own a computer that runs at 2.5 PHz CPU speed, has half of a petabyte (a thousand terabytes) of memory, one quarter of an exabyte (a billion gigabytes) of hard disk-equivalent storage, and will connect to the Internet with a bandwidth of an eighth of a terabit (a trillion binary digits) per second.[126]

So, Dr Tinari suggests that the computers of 2030 will be half-a-million times more powerful than today's machines. My view, however, is that he has underestimated. His projections seem to ignore the evidence that the rate of exponential change is itself speeding up exponentially and he also has done his calculations from a starting assumption that Moore's law is still holding at eighteen months when there is considerable evidence that it is currently running at twelve months or even less.

And, in an interview given to InstaPundit.com Ray Kurzweil laid out his own prediction for computing speeds in 2030:

> By 2030, a thousand dollars of computation will be about a thousand times more powerful than a human brain. Keep in mind also that computers will not be organized as discrete objects as they are today. There will be a web of computing deeply integrated into the environment, our bodies and brains.[127]

Given these two very different methods of predicting the future speeds of computers let me conclude this section by adding that my view is that the networked computers of 2030 will be at least several million times more powerful than today's machines, a prediction, which if correct, will carry vast implications for the future of humankind.

The 'Always On, Always Connected' Society

I suggested earlier that we often lack a language with which to describe a new technology or a concept. We are just entering a startling period in which the internet, the Web, cellular telephony, television, radio and wireless communication will all merge to become a new global 'communications medium.' This new 'medium' (and what a poor, underpowered term that word is) is one in which people and things will be 'always on, always connected, everyone to everyone, everything to everything, always and everywhere'.

That last long-winded and very wordy sentence was necessary because we don't yet have a word or a phrase to describe such a pervasively connected electronic firmament. But even though we are just starting to build this new habitat for humankind, and we lack the language necessary to describe it, the technology will be in place, fully mature and available at very low cost in all countries of the world (and in space and on at least one other planet) by the year 2030.

Everybody is familiar with the internet and its graphical interface, the World Wide Web. Everybody is familiar with cellular phones, television and radio. The new components in this merged 'wireless super-web' are minute intelligent machines that will communicate with each other wirelessly. At its simplest these machines maybe no more than plastic Radio Frequency Identification Tags (RFID tags[128]) that send out self-identifying signals and data when interrogated by a nearby wireless scanner. On a more complex level, machine sensors will be embedded in bridges and other vital structures to transmit data about stress loading and construction integrity. Machines transmitting wireless signals will travel our bodies sending out information about our physical condition and, to pick just one further example, firemen in burning buildings will all wear wireless sensors that send back their position and details of the conditions they are encountering.

Soon, almost everything in the world will become attached to this 'enlarged internet' for which we do not yet have a name. All sorts of technologies will be employed from traditional internet protocol communications to cellular radio signals, stand-alone wireless communications and satellite transmissions. In the end all of these discrete technologies will become one and the same thing: a global communications 'mesh' in which everything from local street lights to a jet plane traveling at 30,000 feet will be connected.

The signs of the emergence of this new 'medium' are already clear to be seen now. A contributor to The Economist reported recently:

> Gizmos and gadgets will talk to other devices – and be serviced and upgraded from afar. Sensors on buildings and bridges will run them efficiently and ensure they are safe. Wireless systems on farmland will

> measure temperature and humidity and control irrigation systems. Tags will certify the origins and distribution of food and the authenticity of medicines. Tiny chips on or in people's bodies will send vital signs to clinics to help keep them healthy.
>
> Imagine how wireless communications could change motoring. Carmakers are starting to monitor vehicles so that they know when to replace parts before they fail, based on changes in vibration or temperature. If there is a crash, wireless chips could tell the emergency services where to come, what has happened and if anyone is hurt. Traffic information can be instantaneous and perfectly accurate. They administer tolls based on precise routes. One American firm leases cars to people with bad credit who cannot get a loan, knowing that if payments are missed it can block the ignition and find the car to repossess it. British insurers offer policies with premiums based on precisely when and where a person drives.[129]

Dr David Clark,[130] a computer scientist at the Massachusetts Institute of Technology who helped develop the internet, believes that in fifteen or twenty years' time the network will need to accommodate a trillion devices, most of them wireless.

Even though we are only at the beginning of the development of what some people have called 'the internet of things', novel and supremely useful applications are emerging. Companies like the giant retailer Wal-Mart[131] are already tracking their inventories with RFID tags and soon shoppers will no longer need to unload their shopping carts at check-out tills. The RFID tags on every item will simply transmit their identities to a scanner and a bill will be presented to customers (who will pay it by waving their mobile devices over the scanner) – and all of these enabling devices will be made largely of plastic, a material that is rapidly becoming 'smart'.

Wireless sensors will make a huge contribution to energy conservation. If every light fixture in a building contained a small wireless node, people

would not only be able to control the lighting more effectively but put them to many other uses too. If the nodes were programmed to serve as online smoke detectors, they could signal a fire as well as show its location. They could also act as a security system or provide internet connectivity to other things in the building. In 'The Hydrogen Economy' Jeremy Rifkin tells us:

> In the very near future, sensors attached to every appliance or machine powered by electricity – refrigerators, air conditioners, washing machines, security alarms – will provide up-to-the-minute information on energy prices, as well as on temperature, light and other environmental conditions, so that factories, offices, homes, neighborhoods and whole communities can continuously and automatically adjust their energy requirements to one another's needs and to the energy load flowing through the system.[132]

The Dutch electronics manufacturer Philips plans to introduce wirelessly controlled lighting systems for commercial buildings by 2012. And the company's researchers are working on making networked light fittings capable of monitoring the objects throughout a building, tracking equipment in hospitals or preventing theft in offices.

In the UK the building services firm Rentokil[133] has added a small plastic sensor and a wireless module to its mousetraps so that they notify the building staff when a rodent is caught. This is a big improvement on traps that need to be regularly inspected. A large building might contain hundreds of them, and a few are bound to be forgotten.

Over the last five years tens of thousands of digital mousetraps have been put in big buildings and venues such as London's new Wembley Stadium. The traps communicate with central hubs that connect to the internet via the mobile network to alert staff if a creature is caught. The system provides a wealth of information. The data it collects and analyses on when and where

rodents are caught enable building managers to place traps more effectively and alert them to a new outbreak.

New examples of ‘machine-to-machine’ (M2M) communications applications are being announced almost every day. In the USA some prisons have already placed location and identification sensors[134] in plastic bracelets worn by all their inmates (and their guards) and they report significant reductions in violence as a result of their use.

By 2030 we will all be ‘tagged’ but it will be for our protection, rather than to restrict out movements (and if you don’t like the idea of humans being ‘tagged’ consider the fact that your mobile phone negotiates with your cellular wireless network 800 times every second and your network always knows where your phone is whenever it is switched on).

We will all transmit our locations constantly, data about our bodies’ vital signs and physiology will be collected and transmitted to ensure our well being and, if we are taken ill, help will be summoned automatically. All soldiers on battlefields will transmit their location, all passengers on underground railways will transmit their location (Londoners, remember the plastic Oyster card you carry is an RFID chip), shop doorways will recognize returning customers and football fans will carry tickets which identify which team they are supporting and whereabouts they are in the stadium. Leaky taps in our buildings will call the plumber themselves and energy-consuming devices will shut themselves down when they sense they are not required.

There will be massive privacy issues when we are all permanently connected, along with our possessions and the environment around us. New laws will be required to protect our rights and new ways of enforcing such legislation will be necessary; but despite these concerns, we are rushing headlong into a fully connected, 'always on, always connected, always and everywhere' future.

This 'permanently connected' environment is stimulating new ways of human interaction as the web itself becomes more powerful. A few years ago a slew of new technologies known under the umbrella term 'Web 2.0'[135] brought significantly enhanced levels of functionality to web communication and processing (and allowed software applications such as word processing and spreadsheets to be used as an inherent part of the web rather than as stand-alone software on individual computers). And, as the web becomes ever more capable, humans are finding new ways to exploit its potential and collaborate in new ways.

Today 'The Cloud' (distributed computing power accessed via the internet) is the buzz concept for corporate users of the 'electronic firmament' and 'social networking' (Facebook, Twitter, et al., the sites that added a 'broadcast' element to the notion of 'chat rooms') are the rage for younger (and some older) people.

As mentioned in the new foreword to this edition social media, and Facebook, Twitter and YouTube in particular, are proving to be major agents of change in the world. The ability to communicate with large groups of people instantly (the sites automate the forwarding of the messages) allows

mass broadcasting to occur without the knowledge of the authorities and, in repressive regimes, such power rapidly becomes very subversive.

But Professor Clay Shirky of New York University pointed out in Foreign Affairs March/April 2011 that the use of 'social media' for the purposes of political organization dates back more than decade:

> It would be impossible to tell the story of Philippine President Joseph Estrada's 2000 downfall without talking about how texting allowed Filipinos to coordinate at a speed and on a scale not available with other media. Similarly, the supporters of Spanish Prime Minister José Luis Rodríguez Zapatero used text messaging to coordinate the 2004 ouster of the People's Party in four days; anti-communist Moldovans used social media in 2009 to turn out 20,000 protesters in just 36 hours; the South Koreans who rallied against beef imports in 2008 took their grievances directly to the public, sharing text, photos, and video online, without needing permission from the state or help from professional media. Chinese anticorruption protesters use the instant-messaging service QQ the same way today. All these actions relied on the power of social media to synchronize the behavior of groups quickly, cheaply, and publicly, in ways that were unavailable as recently as a decade ago[136].

And Facebook and others (including dictators) had plenty of warning about the power of social media to upset the status quo. Writing in his 2010 book 'The Facebook Effect' David Kirkpatrick pointed out:

> In Egypt, demonstrators in 2009 organized on Facebook to protest a proposed law that would limit bandwidth consumed by internet users. Shortly afterward, the minister of communications significantly amended the plan to address their concerns. In a county like Egypt, where public protest canlead to torture and arrest, such successes are especially striking[137].

As the uprising in the Arab world got under way in early 2011 governments tried to cut off such communication by shutting down internet access, but this proved very difficult to achieve. In Spring 2011 The Economist reported on some of the ways that political activists regain access to the internet after authorities attempt to disconnect the nation:

> With a tin can, some copper wire and a few dollars' worth of nuts, bolts and other hardware, a do-it-yourselfer can build a makeshift directional antenna. A mobile phone, souped-up with such an antenna, can talk to a network tower that is dozens of kilometres beyond its normal range (about 5km, or 3 miles).
>
> …According to Jeff Moss, a communications adviser to America's Department of Homeland Security, their existence has recently been valuable to the operation of several groups of revolutionaries in Egypt, Libya and elsewhere. To get round government shutdowns of internet and mobile-phone networks, resourceful dissidents have used such makeshift antennae to link their computers and handsets to more orthodox transmission equipment in neighbouring countries.
>
> Technologies that transmit data under the noses of repressive authorities in this way are spreading like wildfire among pro-democracy groups, says Mr Moss. For example, after Egypt switched off its internet in January some activists brought laptops to places like Tahrir Square in Cairo to collect, via short-range wireless links, demonstrators' video recordings and other electronic messages. These activists then broadcast the material to the outside world using range-extending antennae[138].

One month earlier the FastCompany website had carried a story about one of the Yemini-Arab facilitators who was helping to make this possible:

> Walid Al-Saqaf's Alkasir is an unsung hero in the recent political overhaul in Egypt and the Arab world. Alkasir - meaning "circumventor" -is what has allowed many ordinary citizens to access Facebook and Twitter and share vital information despite government blocks.
>
> "Given that the Arab world is suffering from political censorship, there is a strong need for this in the region," Al-Saqaf tells *Fast Company*.

> The site uses a "split tunnel" technology to help people access blocked websites and map censorship by verifying filtering of websites around the world. And part of its grassroots success is that it only focuses on blocked sites for ideas and opinion-sharing. And it feeds off of word of mouth. "I didn't carry out formal marketing and that was intentional. I wanted people to investigate and find out on their own," says Al-Saqaf.
>
> Timing was key, too. "People in Egypt were in a panic," Al-Saqaf says. "They didn't know what to do and they would email me saying they were so thankful. For some websites, you can't even use proxies. But people would download this program and then they would be able to access updated reports." And once people found out about the service, they would then tweet about it, which helped to spread the word[139].

As I write protests organized by 'broadcasts' on Facebook and Twitter are continuing, although abating somewhat, in Bahrain, Yemen, Jordan, Syria and, to a lesser extent, in Saudi Arabia. Most are being met with repressive force.

In March 2011 The Jordan Times reported:

> Syrians are organising campaigns on Facebook and Twitter that call for a "day of rage" in Damascus this week, taking inspiration from Egypt and Tunisia in using social networking sites to rally their followers for sweeping political reforms.
>
> Like Egypt and Tunisia, Syria suffers from corruption, poverty and unemployment. All three nations have seen subsidy cuts on staples like bread and oil. Syria's authoritarian president has resisted calls for political freedoms and jailed critics of his regime.
>
> The main Syrian protest page on Facebook is urging people to protest in Damascus on February 4 and 5 for "a day of rage". It says the goal is to "end the state of emergency in Syria and end corruption".
>
> The number of people who have joined Facebook and Twitter pages calling for protests on Friday and Saturday is still relatively small, and some are believed to live outside the country.
>
> Social networking sites were integral to rallying protesters in Tunisia and Egypt.

> Facebook is banned in Syria, which makes organising more difficult - even though many Syrians manage to access the social networking site anyway. More than 2,500 people have joined the page calling for protests on February 4-5, with another 850 joining a page in favor of President Bashar Assad[140].

It remains to be seen whether people power (aided by social media web sites) will prevail. The probably is that they will succeed in some states and not in others – local conditions, demography and ethnic cohesion/division play major roles.

Other autocratic non-democracies such as China regarded the uprising in the Middle East with considerable alarm and, in response, tightened its grip further on internet control – including a complete block on Facebook.

This new, emerging 'wireless firmament' (for want of a better phrase) will be the place where we chat, play, conduct business, earn money, administer government, plan revolutions, learn, fall in love, have sex, store our memories, remember and honour the dead, and connect all of our loved ones and friends, our inanimate objects and ourselves. It is humanity's future.

This is not a new idea to me. Nearly thirty years ago I wrote 'The On-Line Handbook'[141] in which I said:

> The electronic web of computer bulletin boards spread around the globe can be seen as an early underground, a system of communication between the ordinary people which is already working faster and more effectively than organized forms of communication such as television.
>
> … The linking of computers around the world is going to have far reaching effects, and the spread of knowledge, the interchange of ideas and the dissemination of information are going to produce a revolution in our society.
>
> The moment you go on-line you feel as though the revolution has sprung down the telephone line and invaded your own room.

> You will know what the wired world is like and you will begin to understand the implications! You become a pioneer of the information age, experiencing with awe the power of linked computers which the next generation will take for granted. [142]

And by 2030 the experience of using this 'super combined web' will also be far more rich and multi-sensory than it is today, but it will be totally invisible and wholly pervasive. 'Internet access', in the absence of future language, will be provided by lamp posts, windows, in trains, on planes, by buildings and by church steeples. It will be 'the internet of the air' in which we, our children, our pets and trillions of inanimate objects (and some very intelligent machines) commune every second of the day.

The high speed super-web of 2030 will deliver 3D holographic images of sports events, dramas, games and sex simulations. The super-web will be able to provide tactile simulations, odours and tastes. The multi-sensory super-web will create virtual experiences that will seem so real they are almost distinguishable from the real thing (and as we sense the 'real thing' solely though our own human sensory apparatus, who is to argue which is the more real?).

In time, perhaps before 2030, our minds will be directly attached to the super-web by a neural interface and, with a thought, we will be able to access the world's entire stock of information, communication, learning, entertainment and leisure activities in full sensory glory. It sounds like science fiction, but by 2030 some people will be enjoying such astonishing access.

Machine Super Intelligence (Strong Artificial Intelligence)

If some of the above has left you breathless, I am afraid that there are more breathtaking ideas to come in this survey of likely (or almost certain) technological development in the next twenty years. The first of these is super-intelligent machines or, to use plain language, machines that are as capable of complex, general purpose behaviour as you or me.

The science of trying to develop super-intelligent machines used to be called 'Artificial Intelligence' (AI) and, in the early 1980s, there was intense debate about how soon AI could be developed and how soon really clever computers would be helping surgeons, controlling traffic flows, running air traffic control and generally making human life better and safer.

But to the outside world the efforts of the AI community appeared to fail and the quest to develop Artificial Intelligence seemed to dissipate and fade away. In reality, it did no such thing; it just developed in ways that were unexpected. Our anthropomorphic impulses led us to assume that a human-like robot would spring from the artificial laboratories of the 1980s ready to become our companion. But twenty years ago we hadn't even begun to understand what a human was either in terms of brain function or physiology. Our chances of building a copy of ourselves at that time were zero.

However, sophisticated machine intelligence (albeit not very human seeming) has been developed and deployed out of the continuing research into what was once called 'artificial intelligence'. Software systems now run and control (with human oversight) jets in flight, air traffic control

systems, human surgery and military weapons systems. These AI systems are robust and extremely useful and our modern world couldn't run without them.

Professor Marvin Minsky[143] of the Massachusetts Institute of Technology in Boston, USA, is widely regarded as the 'father of artificial intelligence'. Speaking to Discover magazine he explained:

> The history of AI is sort of funny because the first real accomplishments were beautiful things, like a machine that could do proofs in logic or do well in a calculus course. But then we started to try to make machines that could answer questions about the simple kinds of stories that are in a first-grade reader book. There's no machine today that can do that. So AI researchers looked primarily at problems that people called hard, like playing chess, but they didn't get very far on problems people found easy. It's a sort of backwards evolution. I expect with our commonsense reasoning systems we'll start to make progress pretty soon if we can get funding for it. One problem is people are very skeptical about this kind of work.[144]

Asked about his book 'The Emotion Machine' Minsky went on to describe the sort of artificial intelligence machine he would like to build today:

> The book is actually a plan for how to build a machine. I'd like to be able to hire a team of programmers to create the Emotion Machine architecture that's described in the book—a machine that can switch between all the different kinds of thinking I discuss. Nobody's ever built a system that either has or acquires knowledge about thinking itself, so that it can get better at problem solving over time. If I could get five good programmers, I think I could build it in three to five years.
>
> We humans are not the end of evolution, so if we can make a machine that's as smart as a person, we can probably also make one that's much smarter. There's no point in making just another person. You want to make one that can do things we can't. [145]

But because 1980s AI research was mistakenly considered to be a failure, current research into developing computers with human-like intelligence and

characteristics and intelligence is no longer called artificial intelligence. The field of study is now called 'super intelligence' or 'strong AI'.

Oxford's Dr Nick Bostrom again:

> Given that superintelligence will one day be technologically feasible, will people choose to develop it? This question can pretty confidently be answered in the affirmative. Associated with every step along the road to superintelligence and enormous economic payoffs.
>
> The computer industry invests huge sums in the next generation of hardware and software, and it will continue doing so as long as there is a competitive pressure and profits to be made. People want better computers and smarter software, and they want the benefits these machines can help produce. Better medical drugs; relief for humans from the need to perform boring or dangerous jobs; entertainment – there is no end to the list of consumer-benefits. There is also a strong military motive to develop artificial intelligence. And nowhere on our path is there any natural stopping point where technophobics could plausibly argue 'hither but not further'.[146]

But how will we know when computers of the future become as intelligent as humans? At this stage it is necessary to explain the 'Turing Test'. Alan Turing[147] was a British mathematician who, while studying at Cambridge, published a paper called 'On Computable Numbers'[148] in 1936. This paper laid the foundations for modern computer science and explicitly described a theoretical machine that we would today call a computer.

During World War II Alan Turing built the world's first computer to enable the British Government to decode Nazi and Japanese encrypted communications and, in 1950, he published a paper called Computing Machinery and Intelligence[149] in which he described a test that could be used to determine when a computer's intelligence came to equal human intelligence.

Now known as the Turing Test[150] the evaluation method involves a human talking to a machine (via a keyboard in Turing's original vision) and holding a complex conversation. When the human in the test is unable to tell whether he or she is talking to a machine or to another human being, the machine is said to have passed the Turing Test.

Today we would add many other features to the test such as emotional responsiveness and humour yet, in essence, Turing's idea remains an ideal evaluation.

In February 2011 IBM pitted it's latest stand-alone super-computer (not connected to the internet) against human contestants in the U.S. TV cryptic game show, 'Jeopardy'. The BBC reported the outcome as follows[151]:

> IBM's supercomputer Watson has trounced its two competitors in a televised show pitting human brains against computer bytes.
>
> After a three night marathon on the quiz show Jeopardy, Watson emerged victorious to win a $1million (£622,000) prize.
>
> The computer's competitors were two of the most successful players ever to have taken part in Jeopardy.
>
> But in the end their skill at the game was no match for Watson.
>
> Ken Jennings had previously notched up 74 consecutive wins on the show - the most ever - while Brad Rutter had won the most amount of money, $3million (£1.9m).
>
> "I for one welcome our new computer overlords," Mr Jennings wrote along with his correct final Jeopardy question.

And software agents (often known as 'bots' – from 'robot software') have already become clever enough to win against humans in such psychologically demanded games as poker. As the New York Times reported in early 2011:

> Bryan Taylor, 36, could not shake the feeling that something funny was going on. Three of his most frequent opponents on an online poker site were acting oddly, playing in ways that were so similar it was suspicious.
>
> Mr. Taylor, who started playing poker professionally in 2008, suspected that he was competing against computers — specifically bots, short for robots — that had been programmed to play poker and beat the odds.
>
> And he was right. After an investigation, the site Mr. Taylor frequented, PokerStars, determined that his opponents had been computers masquerading as people and shut them down.
>
> Poker bots are not new, but until recently they were not very good. Humans were better at the nuances of the game — at bluffing, for instance — and could routinely beat the machines. But artificial intelligence has come a long way in the last few years, far enough that poker bots are now good enough to win tens of thousands of dollars on major game sites, which are clamping down on them[152].

So when are we likely to meet computers which approach human levels of capability? This is Ray Kurzweil's prediction:

> Once we've succeeded in creating a machine that can pass the Turing test (around 2029), the succeeding period will be an era of consolidation in which nonbiological intelligence will make rapid gains.
>
> Once strong AI is achieved, it can readily be advanced and its powers multiplied, as that is the fundamental nature of machine abilities. As one strong AI immediately begets many strong AIs, the latter access their own design, understand and improve it, and thereby very rapidly evolve into a yet more capable, more intelligent AI, with the cycle repeating itself indefinitely. Each cycle not only creates a more intelligent AI but takes less time than the cycle before it, as is the nature of technological evolution (or any evolutionary process). The premise is that once strong AI is achieved, it will immediately become a runaway phenomenon[153] of rapidly escalating superintelligence.[154]

And this is what Mr Kurtzweil had to say regarding Watson's successful performance against human contestants of 'Jeopardy'[155]:

> What does this achievement with "Jeopardy!" tell us about the prospect of computers passing the Turing test? It certainly demonstrates the rapid progress being made on human language understanding. There are many other examples, such as CMU's Read the Web project, which has created NELL (Never Ending Language Learner), which is currently reading documents on the Web and accurately understanding most of them.
>
> With computers demonstrating a basic ability to understand the symbolic and hierarchical nature of language (a reflection of the inherently hierarchical nature of our neocortex), it is only a matter of time before that capability reaches Turing-test levels. Indeed, if Watson's underlying technology were applied to the Turing test task, it should do pretty well.

Those of you who struggle daily with incalcitrant and mind-numbingly stupid PCs may think Kurzweil's prediction of a machine that could pass the Turing Test by 2029 as ludicrous but, as well as pointing out the achievements of Watson, I ask you to examine the rapidly changing nature of Google and other internet search engines. Have you noticed that Google, in particular, seems to become 'smarter' every day? This is not an accident.

Larry Page,[156] one of the two founders of Google, told an audience in New York four years ago:

> 'We have some people at Google who are really trying to build artificial intelligence and to do it on a large scale. It's not as far off as people think.'[157] (There's a video of Larry Page talking further on this subject here.[158])

And in later the same year Google's then CEO Eric Schmidt told the Financial Times that the search engine hopes to provide practical advice to its users about their major life decisions:

> Google's ambition to maximise the personal information it holds on users is so great that the search engine envisages a day when it can tell people what jobs to take and how they might spend their days off.

> Eric Schmidt, Google's chief executive, said gathering more personal data was a key way for Google to expand and the company believes that is the logical extension of its stated mission to organise the world's information.
>
> 'The goal is to enable Google users to be able to ask the question such as "What shall I do tomorrow?" and "What job shall I take?" ' [159]

I think Google is no less than an awakening global brain, such as I imagined in my 2001 novel, 'Emergence'[160] (the title refers to the phenomenon of consciousness 'emerging' from within a dense global network). And I don't think I am being fanciful. Google holds much of the world's information in its vast databases and it holds search histories and the preferences of all the people who have ever used the service. The knowledge of what the world's internet-using population wants, and in what territories of the world, is like having the ultimate guide to the global Zeitgeist. Couple that with rapidly developing computer intelligence and it is not hard to see where the first signs of human-like intelligence in a computer system are likely to be encountered.

How will we cope with machines that are as intelligent, or more intelligent than ourselves? Bill Hibbard,[161] Emeritus Senior Scientist at the Space Science and Engineering Center in Wisconsin, and the author of 'Superintelligent Machines' suggests:

> A critical event in the progress of science is imminent. This is the physical explanation of consciousness and demonstration by building a conscious machine.
>
> We will know it is conscious based on our emotional connection with it. Shortly after that, we will build machines much more intelligent than humans, because intelligent machines will help with their own science and engineering.

> And the knowledge gap that has been shrinking over the centuries will start to grow. Not in the sense that scientific knowledge will shrink, but in the sense that people will have less understanding of their world because of their intimate relationship with a mind beyond their comprehension. We will understand the machine's mind about as much as our pets understand ours. We will fill this knowledge gap with religion, giving the intelligent machine the role of god. [162]

In his book 'Beyond AI: Creating the Conscience of the Machine', Dr J. Storrs Hall,[163] Research Fellow of the Institute for Molecular Manufacturing in Palo Alto, California, describes the abilities of an artificial intelligence of what he calls and 'epihuman' (just above human level) of intelligence:

> My model for what an epihuman AI would be like is to take the ten smartest people you know, remove their egos, and duplicate them a hundred times, so that you have a thousand really bright people willing to apply themselves all to the same project. Alternatively, simply imagine a very bright person given a thousand times as long to do any given task. We can straightforwardly predict, from Moore's law, that ten years after the advent of a learning but not radically self-improving human-level AI, the same software running on machinery of the same cost would do the same human-level tasks a thousand times as fast as we. It could, for example:
>
> – read an average book in one second with full comprehension;
>
> – take a college course and do all the homework and research in ten minutes;
>
> – write a book, again with ample research, in two or three hours;
>
> – produce the equivalent of a human's lifetime intellectual output, complete with all the learning, growth, and experience involved, in a couple of weeks.[164]

Perhaps the last word on superintelligent machines should go to Irving John Good[165] (one of the British World War II cryptographers who worked alongside Alan Turing), author of the 1965 paper, 'Speculations Concerning the First Ultraintelligent Machine':

> Thus the first ultraintelligent machine is the last invention that man need ever make.[166]

Nanotechnology

The term 'nanotechnology'[167] is simple to define (the control of matter on a scale smaller than 1 micrometer, normally between 1-100 nanometers) but the types of science and technology being developed at this sub-microscopic level vary greatly.

This area of research was first identified by the legendary physicist Professor Richard P. Feynman[168] in his seminal 1959 lecture entitled 'There's Plenty Of Room At the Bottom'[169] in which he proposed that much could be achieved by scientists who chose to work at the atomic level. But the field of nanotechnology only began to develop properly in the mid-1980s when a graduate PhD student called Eric Drexler[170] wrote a thesis which went on to become a highly influential book called 'Nanosystems Molecular Machinery Manufacturing and Computation'. [171] Serious scientific research began at that point.

Nanotechnology can be used to produce materials with special properties (e.g. antiseptic, anti-UV, fire-resistant, heat-absorbing, stain resistant and electrical conducting functions) but the term also encompasses research into engineering at a molecular level, experimentation that is expected to lead to truly astonishing developments.

Molecular nanotechnology[172] (MNT) when fully developed will, theoretically, allow us to construct almost anything from the atomic level up,

including food, water, computers and even nano-scale robots which will carry drugs to the precise site at which they are needed in the human body.

Nano optimists,[173] including many governments (and futurists), see nanotechnology delivering environmentally benign material abundance for the world's population by providing universal clean water supplies; atomically engineered food and crops resulting in greater agricultural productivity with less labour and land requirements; nutritionally enhanced interactive 'smart' foods; cheap and powerful energy generation; clean and highly efficient manufacturing; radically improved formulation of drugs, diagnostics and human organ replacement; much greater information storage and communication capacities; interactive 'smart' appliances; and increased human performance through convergent technologies.

Critics of MNT development[174] suggest that nanotechnology will simply exacerbate problems stemming from existing socio-economic inequity and the unequal distribution of power by creating greater inequities between rich and poor through an inevitable nano-divide (the gap between those who control the new nanotechnologies and those whose products, services or labour are displaced by them); destabilizing international relations through a growing nano arms race and increased potential for bioweaponry; providing the tools for ubiquitous surveillance, with significant implications for civil liberty; breaking down the barriers between life and non-life through nanobiotechnology, and redefining even what it means to be human. Some suggest[175] that nano-scale molecules could even escape into the environment and self-replicate, taking over the world as a 'grey goo'[176] which will consume everything.

Whatever the potential benefits and dangers of the technology almost all futurists and futurologists agree that nano-scale engineering will become possible in the next few decades, but few of us can be sure when the products of this science will begin to emerge.

Ray Kurzweil writes on his web-site:

> Although most nanotech projects today focus on structural nanotechnology, development of molecular nanotechnology will surely become a priority within a few years. Full MNT capability may not be developed for a decade or longer, but preparation for it should probably start now.
>
> The economic value – and military significance – of a nanofactory will be immense. Even a primitive model will be able to convert CAD files to products in a few hours. Duplicate nanofactories will cost the same as any other nano-built product. The capital cost of manufacturing will be negligible by today's standards, and manufacturing capacity can be doubled in a matter of hours.[177]

In 'The Extreme Future' Dr James Canton sees nanotechnology potentially offering a similar bonanza:

> Nanoscience represents a radical change in material science, drugs, devices, and manufacturing. Nano-based products could change everything, reducing functions down to 100,000 times smaller than a human hair. Total nanotech investments worldwide were more than $10 billion in 2005. By 2008, the nanomarket may grow to more than $32 billion worldwide. Nanomaterials will drive the near-term market growth, while nano-devices will dominate future growth. [178]

The implications of the coming nanotech revolutions are extreme and by 2030 we will be in the thick of it with astonishing new applications enriching (and, perhaps, potentially endangering) our physical world. Nanotech is one of the more extreme 'wild cards' in the technology pack and it is possible that some of the problems examined elsewhere in this report could be completely or partially solved by the science (e.g. nanotech might

provide new sources of clean energy). In 2003 the late Professor Richard Smalley[179] of Rice University in Texas – a Nobel Laureate prize winner for his chemistry research – delivered a lecture called 'Nanotechnology, the S & T Workforce, Energy & Prosperity'. In the lecture he described fourteen ways in which he thought nanotech will affect society:

14 Enabling Nanotech Revolutions

1. Photovoltaics – a revolution to drop cost by 10 to100 fold.

2. H_2 (hydrogen) storage – a revolution in light-weight materials for pressure tanks, and/or a new light weight, easily reversible hydrogen chemisorption system

3. Fuel cells – a revolution to drop the cost by nearly 10 to 100 fold

4. Batteries and super capacitors – revolution to improve by 10-100x for automotive and distributed generation applications.

5. Photo catalytic reduction of CO_2 to produce a liquid fuel such as methanol.

6. Direct photo conversion of light + water to produce H_2 (hydrogen)

7. Super-strong, light weight materials to drop cost to LEO, GEO (space orbit paths), and later the moon by > 100 x, to enable huge but low cost light harvesting structures in space; and to improve efficiency of cars, planes, etc.

8. Nanoelectronics to revolutionize computers, sensors and devices.

9. High current cables (superconductors, or quantum conductors) with which to rewire the electrical transmission grid, and enable continental, and even worldwide electrical energy transport; and also to replace aluminum and copper wires essentially everywhere – particularly in the windings of electric motors (especially good if we can eliminate eddy current losses).

10. Thermo chemical catalysts to generate H_2 from water that works efficiently at temperatures lower than 900° C.

> 11. CO_2 mineralization schemes that can work on a vast scale, hopefully starting from basalt and having no waste streams.
>
> 12. Nanoelectronics-based Robotics with AI to enable construction maintenance of solar structures in space and on the moon; and to enable nuclear reactor maintenance and fuel reprocessing.
>
> 13. NanoMaterials/coatings that will enable vastly lower the cost of deep drilling, to enable HDR (hot dry rock) geothermal heat mining.
>
> 14. Nanotech lighting to replace incandescent and fluorescent lights.[180]

Clearly molecular-level nano-engineering will have the most profound impact on our future. But however weird and futuristic molecular nanotech manufacturing may sound today as we approach 2030 almost everything will be overshadowed by a rapidly approaching rupture in human evolution.

The Technological Singularity

In the summer term of 1965, I persuaded my sixth form school colleagues (16-18 year olds) that we should hold a debate on the topic, 'Man Will Transfer His Mind To Machines.' I was the main proposer and supporter of the motion which I duly lost comprehensively.

Now, almost fifty years later, we can contemplate a time when it will be necessary for us not only to consider the moral and ethical issues of transferring a human mind to a machine but to consider how we should respond when machine intelligence becomes more capable than human intelligence.

These ideas on the likely shape of the world in 2030 is certain to be the most controversial and, for many readers, will seem the most far fetched, as

it describes a period in which machines become as clever as humans and in which humans will enhance their own biology to rival the machines they are building. The period immediately after the point at which machine intelligence exceeds human capabilities is becoming known as 'the technological singularity'.

'The Technological Singularity'[181] is a phrase adopted by futurists, futurologists and computer scientists to describe the time when human intelligence is no longer the dominant form of intelligence on Earth. Usually we lack appropriate language for the technological future but, in this instance, I think the term 'technological singularity' is appropriate, even if it is somewhat opaque. In astronomy a 'singularity' is an event horizon beyond which nothing can be seen. The coming singularity in human evolution is similar; once machines are more clever than humans they will create a world which is impossible for unenhanced humans to imagine. The development will be, indeed, a singularity in human affairs.

The term 'singularity' was first applied in the context of human-machine evolution by Vernor Vinge,[182] a professor of mathematics at San Diego State University. In a paper written in 1993 he began as follows:

> Within thirty years, we will have the technological means to create superhuman intelligence. Shortly after, the human era will be ended.
>
> Is such progress avoidable? If not to be avoided, can events be guided so that we may survive? These questions are investigated. Some possible answers (and some further dangers) are presented.
>
> The acceleration of technological progress has been the central feature of this century. I argue in this paper that we are on the edge of change comparable to the rise of human life on Earth. The precise cause of this change is the imminent creation by technology of entities with greater than human intelligence. There are several means by which science may

> achieve this breakthrough (and this is another reason for having confidence that the event will occur).[183]

Much work of the subject has been done since 1993 and writing in 1994 researcher Dani Eder of the Boeing AI Center[184] speculated:

> When will the Singularity Occur?
>
> The short answer is that the near edge of the Singularity is due about the year 2035 AD. Several lines of reasoning point to this date. One is simple projection from human population trends. Human population over the past 10,000 years has been following a hyperbolic growth trend.
>
> Since about 1600 AD the trend has been very steadily accelerating with the asymptote located in the year 2035 AD. Now, either the human population really will become infinite at that time, or a trend that has persisted over all of human history will be broken. Either way it is a pretty special time.
>
> Since computer capacity doubles every two years or so, we expect that in about 40 years, the computers will be as powerful as human brains. And two years after that, they will be twice as powerful, etc. And computer production is not limited by the rate of human reproduction. So the total amount of brain-power available, counting humans plus computers, takes a rapid jump upward in 40 years or so. 40 years from now is 2035 AD.[185]

In 1995 biologist and writer Dr Steve Alan Edwards[186] wrote an article for the Australian 21C web site (21st Century magazine) in which he described the growing army of 'singularitists' and 'tranhumanists' and discussed their goals:

> Wouldn't it be really great if we, by packaging ourselves into a machine (or a machine into ourselves) could somehow achieve that greater-than-human intelligence, and become our own evolutionary successors?
>
> Wouldn't it be great if we could survive the Singularity?
>
> Meet the Transhumanists – an Internet-connected virtual community of futurists whose stated goal is self-transcendence through technology. International in scope, though few in number, transhumanists tend to be

> young, intelligent, and technologically literate – often graduate students in neuro- or information science.
>
> Along with (Vernor) Vinge, their intellectual heroes include roboticist Hans Moravec, artificial intelligence pioneer Marvin Minsky, nanotechnology guru K. Eric Drexler, and physicist/cosmologist Frank Tipler.
>
> Moravec and Minsky have argued for the theoretical feasibility of 'mind-uploading' wherein a person's mind and personality could be emulated by a computer. Drexler has argued that the Singularity is even closer than we think, driven by – you guessed it – nanotechnology, the science of creating objects by controlling matter on a molecular scale. Tippler's cosmological scheme holds that the universe is evolving into a giant supercomputer which he chooses to call the Omega Point – but is, perhaps, indistinguishable from God.[187]

There are many different routes to The Singularity. I wrote earlier that the world's networks and the billions of computers which will be attached to it may prove to have emergent qualities of consciousness and super-intelligence on their own. As Professor Marvin Minsky wrote in one of his most famous books, 'Society of Mind' (1988),:

> This book tries to explain how minds work. How can intelligence emerge from nonintelligence? To answer that, we'll show that you can build a mind from many little parts, each mindless by itself.
>
> I'll call 'Society of Mind' this scheme in which each mind is made of many smaller processes. These we'll call agents. Each mental agent by itself can only do some simple thing that needs no mind or thought at all. Yet when we join these agents in societies - in certain very special ways - this leads to intelligence.[188]

But perhaps the most remarkable 21st Century work on the subject is Ray Kurweil's previously quoted book 'The Singularity is Near.' In it, Kurzweil suggests:

> Once we've succeeded in creating a machine that can pass the Turing test (around 2029), the succeeding period will be an era of consolidation in which nonbiological intelligence will make rapid gains.

> However, the extraordinary expansion contemplated for the Singularity, in which human intelligence is multiplied by billions, won't take place until the mid 2040s.[189]

Because he thinks the Technological Singularity to be such an urgent and pressing issue for society to deal with, Ray Kurzweil and others established The Singularity Institute For Artificial Intelligence in California in 2009. The institute works in conjunction with Stanford University to present courses and conferences on AI and the Singularity.

Clearly, it is impossible to be precise about when the Technological Singularity will occur, but it will be the most momentous development in human evolution since our species discovered language and began using tools (the earliest form of technology).

There are many who will be sceptical about the notion of machines ever becoming more capable than humans but, after forty years of observing technological progress, I personally have little doubt that this will be achieved, and probably soon after this book's time line of 2030. And, despite my robust defeat in the debate I sponsored in 1965, I have little doubt that later this century humans will be begin to upload their minds and their memories to machines.

Of course, the idea of super intelligent machines becoming our successors (with or without our brains uploaded into them) is not new, or even a product of 20th Century thinking. In 1864, Samuel Butler,[190] a writer, philosopher and New Zealand sheep farmer, wrote to Charles Darwin, the man who first developed the theory of evolution, suggesting a new chapter to end Darwin's famous 'Origin Of The Species':

> Who will be man's successor? To which the answer is: We are ourselves creating our own successors. Man will become to the machine what the horse and dog are to man; the conclusion being that machines are, or are becoming, animate.[191]

But even as machines are developed to become a new form of life by human efforts, we humans will be changing ourselves into a more capable, more durable and longer-lived species (as I discuss in my later section on 'Human Health And Longevity').

What will happen after the singularity? As I mentioned above, post-singularity events cannot be predicted or even imagined with any degree of certainty by the unaided human minds of the early twenty-first century. But I have long been of the opinion that human evolutionary destiny is to merge human biology with machine intelligence to create a successor species, a semi-plastic species which, freed of biological time constraints, will be free to leave this planet and begin to colonise the universe with a form of intelligence that, because of our lack of language for the future, can only be described as post-human.

Part Two

Climate Change And The Environment

Consulting Referee:
Mike Childs,
Head of Campaigns,
Friends of the Earth

CNN Online News: Europe, 18 October, 2030.

WINTER ICE GRIPS EUROPE AGAIN

Harbors around Ireland and the United Kingdom are already being closed by autumnal ice floes and the whole of Western Europe is bracing itself to face yet another frozen winter.

Since climate change reached a tipping point ten years ago and the Atlantic conveyor stopped working (the conveyor was a system of underwater currents which brought the warm waters of the Gulf Stream up to Europe) millions have fled their homes in Ireland, the UK, Holland, Scandinavia, the Benelux, Germany and Northern France to find better living conditions in the Southern Europe and even in North Africa.

The economic impact of failing agriculture and forced migration over the last decade has been devastating, with national GDPs falling by up to 50 per cent across the affected regions. Food aid and economic assistance has been provided in large measure by Russia, Asia and Canada to help the plight of millions of European refuges fleeing Siberian conditions.

Evidence of past climate patterns found buried in rocks and sediments (paleoclimatic evidence) suggests that these abruptly altered climatic patterns in Europe could last for as much as a century, as they did when

> the ocean conveyor last collapsed 8,200 years ago, or, at the extreme, could last as long as 1,000 years as they did during the Younger Dryas period, which began about 12,700 years ago.

The fictional paragraphs above are not a prediction of the results of climate change produced for this report. They are an extrapolation from a 'worst case' prediction made by US defence advisors in a 2003 report entitled 'An Abrupt Climate Change Scenario and Its Implications for United States National Security'.[192]

The report's authors, Peter Schwartz,[193] a CIA consultant and former head of planning at Royal Dutch/Shell Group, and Doug Randall[194] of the California-based Global Business Network,[195] are two highly respected future scenario planners.

Schwartz and Randall went on to add that in the worst case scenario annual average temperatures would drop by up to five degrees Fahrenheit over Asia and North America and six degrees Fahrenheit in northern Europe. They suggested that annual average temperatures would increase by up to four degrees Fahrenheit in key areas throughout Australia, South America, and southern Africa and, they predicted, drought would persist for most of the decade (the 2020s) in critical agricultural regions and in the scarce water resource regions for major population centers in Europe and eastern North America.

In addition they postulated that winter storms and winds would intensify, amplifying the impacts of the changes. Western Europe and the North Pacific, in particular, would experience enhanced winds. The document

concludes by predicting that abrupt climate change could bring the planet to the edge of anarchy as unstable countries develop a nuclear threat to defend and secure dwindling food, water and energy supplies. The authors added that climate change as a threat to global stability vastly eclipses that of terrorism.

The George W. Bush White House administration suppressed the report,[196] but concerned individuals leaked it to the press and it is now in the public domain.

OK, so that report painted a worst case scenario. What's the best predicted outcome of climate change, and what's the middle ground? And, more importantly how real and urgent is the threat?

In August 2001 I travelled to the South Pacific ocean to discover for myself the effects of climate change on sea levels. As a former science journalist I knew the importance of evaluating evidence at first hand (even if I hadn't then fully appreciated the seriously damaging effect of air travel).

Like many others, I had been exposed for some years to arguments for and against the phenomenon that is commonly called 'global warming' and although I'd read a lot of the original scientific evidence for myself, nothing beats a personal inspection.

I visited Samoa, Tuvalu and several other islands in the South Pacific. On each island I went into the coastal villages, sought out the older men and asked if they would be kind enough to show me their beaches.

Without exception, these village elders pointed out to sea, sometimes dozens of metres out to sea, and indicated where the sea level had been when they had been young, fifty or sixty years before. One of the men on Samoa asked me to wade out into the surf with him to find a rock, now submerged, on which he had stood to fish when he was a child. The transparent, turquoise water was almost up to my chest before he found the rock and, after he had helped me clamber up beside him, we turned to look back at the new shore line. It was at least twenty metres further inland.

Today, most of the beaches on the smaller South Pacific islands are no more than a metre or two wide and in many places the sea has encroached onto what were once village greens. Villagers have had to cut down rain forest to move their communities further into the interior.

Ocean levels rise for many reasons. Over long cyclic periods the Earth's sea levels rise and fall naturally, but there is no previous record of oceans levels rising at such a rapid rate[197] as they have in the past half century, and particularly over the last fifteen years. Not all the extra water comes from the melting of the ice caps,[198] although this has surely been occurring. There is also run off from thousands of land-locked glaciers[199] and, of course, water itself expands[200] when it is heated.

Responsible scientists suggest that all three causes have contributed to the sudden rise in global ocean levels but, whatever the reason, the effect was clear to see. I incorporated my research into a novel that was published in 2005 in which the main action takes place in the year 2055. In my fictional

story climate change has run out of control and humankind is attempting to use advanced technology to bring the climate back under control. The book is called 'Extinction'[201] (the clue to the outcome is in the title).

Some highly qualified and distinguished scientists who approach the issue of climate change from a far more rigorous scientific standpoint than me, draw a similar conclusion as to the possible outcome. Only what *they* are describing is non-fiction and may become all too real. This is what Professor James Lovelock wrote in The Independent in May 2004:

> Unless we stop now, we will really doom the lives of our descendants. If we just go on for another 40 or 50 years faffing around, they'll have no chance at all, it'll be back to the Stone Age. There'll be people around still. But civilisation will go.[202]

James Lovelock is, of course, the scientist who invented the means of measuring chlorofluorocarbons[203] (CFCs) in the atmosphere. These molecules were widely used in aerosols and fridges and they were destroying the protective ozone layer around the planet. As a result of his demonstrations the international Montreal Protocol[204] to outlaw CFCs was signed in 1987. Since 1995 the developed nations have ceased to produce these propellants and coolants for aerosols and fridges in 1995. Now the ozone holes have started to shrink again.[205] Had the ozone layer continued to deplete, millions of us would have died prematurely of skin cancers resulting from excess ultraviolet radiation reaching the planet's surface.

James Lovelock is also the man who produced the 'Gaia' theory'[206] of the Earth, suggesting that this planet is like a superorganism in which every part is dependent on every other part. Whether you choose to believe in the

more mystical and spiritual interpretations of Gaia is up to you, but it is clear that many parts of this planet's environment are indeed closely interlinked.

Lovelock is not alone in forecasting an apocalypse caused by climate change. James Canton, a futurist who has advised former White House administrations writes:

> I am not an alarmist, but there is abundant evidence that climate change and environmental threats present a real and present danger to life as we know it on the planet. If we do not fix this problem, the safety, health and survival of the world's population is at stake.[207]

And Australian writer and zoologist Professor Tim Flannery agrees. As he puts it in his acclaimed book 'The Weather Makers':

> When we consider the fate of the planet as a whole, we must be under no illusions as to what is at stake. Earth's average temperature is around 15ºC and whether we allow it to rise by a single degree, or 3ºC, will decide the fate of hundreds of thousands of species and most probably billions of people. Never in the history of humanity has there been a cost-benefit analysis that demands greater scrutiny…
>
> If humans pursue a business-as-usual course for the first half of this century, I believe the collapse of civilisation due to climate change becomes inevitable.[208]

Even politicians have been bold enough to cast the future in similar terms. Tony Blair, one of the world's politicians who was most engaged with the problems of climate change while in office said in 2004:

> The emission of greenhouse gases…is causing global warming at a rate that began as significant, has become alarming and is simply unsustainable in the long term. And by long term I do not mean centuries ahead. I mean within the lifetime of my children certainly; and possibly within my own. And by unsustainable, I do not mean a phenomenon causing problems of adjustment. I mean a challenge so far-reaching in its impact and irreversible in its destructive power, that it alters radically human existence…There is no doubt that the time to act is now.[209]

A year later Britain's then Chancellor of the Exchequer, Gordon Brown, commissioned Sir Nicholas Stern to research and to write a report on climate Change. When the Stern Review[210] was published in October 2006 it caused a sensation. Addressing the United Nations Sir Nicholas's views were reported as follows:

> Mr. Stern warned that 'even if we are sensible about climate change and get the emissions down, the climate is going to change still more than it has'. While the world was currently experiencing the effects of an increase in global temperatures of 0.7 degrees Celsius, he said that 'even if we act strongly to decrease emissions, we've got another 1.5 to 2.0 degrees centigrade to come. So we've seen maybe a quarter or a third of temperature increase we're going to have to cope with. St. Petersburg, New York, London, Cairo, Cape Town, Shanghai, Bombay, Calcutta, Dhaka - they're all under threat from sea-level rise, and many parts of the world will be under threat from hurricanes, typhoons, droughts and floods.'
>
> Mr. Stern also warned that the heatwaves that killed thousands of people in Europe in 2003 'will probably be standard by the time we get to 2050', and the Nile river, which ten countries depend on, could drop to one half of current water levels in the second half of this century. However, the 'business as usual' scenario-where no action is taken to reduce emissions- would lead to changes in the earth's climate, he said, 'that we don't really understand, absolutely unprecedented and earth-transforming – the difference between where we are now and the last ice age.'[211]

And a year later Angela Merkel, Chancellor of Germany and then President of the European Union told the Financial Times why she had pushed for EU agreement[212] on significant carbon reductions by 2020 :

> We made a choice: We could have muddled through and looked away because it was not clear what the cost (of climate change) was going to be. Instead, we decided to act under the assumption that, whatever happens, the cost of inaction will be higher. This, as made clear by the Stern report, is the main paradigm change.[213]

The Fuzz On The Skin Of A Peach

If you want to picture Earth's atmosphere, think of the white fuzz on the skin of a peach. In relative terms, that fuzz is the same thickness as our planet's atmosphere. To use another simile, it is as thick as an onion's outmost layer.

Yet, despite being so thin, this clinging strata of gases is what makes Earth unique among all the other planets known to humankind. This thin coating of atmosphere[214] has brought life to Earth and all of our teaming, swarming diversity of biology relies totally on this invisible, fragile and threatened halo.

It is impossible to know for sure how much more heated the planet's atmosphere will have become in twenty years, partly because so much depends on our actions over the next two decades. What is clear is that mankind's activities are almost certainly causing the climate to warm up in an unnatural and dangerous way. The United Nation's Intergovernmental Panel On Climate Change[215] (the IPCC) produced a report[216] as the first edition of this book was being written which stated that it is '90 per cent likely' that human activity is responsible for global warming. They said the evidence was 'unequivocal.'

Here are just three of the IPCC's conclusions (with links to the data sources);

1). World sea levels are rising 50 per cent faster[217] today than predicted in the last IPCC report in 2001.

2). The Gulf Stream has slowed by about 30 per cent[218] between 1957 and 2004.

3). The IPCC itself says there's a dangerous lag with atmospheric warming. Eighty per cent of the extra heat currently being trapped by greenhouse gases is being drawn into the oceans. As the oceans warm, more of that heat will remain in the air. Even if emissions were sharply reduced, the world would continue to warm by 0.1° C per decade for some time.

Over 2000 scientists specialising in studying climate change and related disciplines contributed to the IPCC report and all had to agree unanimously with the report's findings. For all reasonable people the debate about whether or not climate change is a real and worrying phenomenon is over. Perhaps the Australian environmentalist Tim Flannery should be allowed the last word on the IPCC's global consensus position on climate change: 'If the IPCC says something, you had better believe it – and then allow for the likelihood that things are far worse than it says they are.'

James Lovelock managed to prod the international community into action over the dangers of CFCs causing ozone depletion. Now there is urgent need for another accord, one far more powerful than the Kyoto Protocol. If we are to stabilize our climate, Kyoto's target needs to be strengthened twelve times over[219] says Tim Flannery: cuts of 70 per cent by 2050 are required to keep CO_2 at double the pre-industrial level.

If we do nothing there will be a doubling of CO_2 in our atmosphere – from three parts per 10,000 that existed in the early 20th Century to six. That has

the potential to heat our planet by around 3°C. and perhaps by as much as 6°C.

If, magically, we were able to stop all greenhouse gas emissions today Earth would continue to heat up from the effect of emissions already generated until the year 2050. CO_2 persists a long time in the atmosphere. Much of the CO_2 released as the world started to recover from the First World War is still warming our planet today.

As Tim Flannery puts it:

> Since the beginning of the Industrial Revolution a global warming of 0.63ºC has occurred on our planet, and its principal cause is an increase in atmospheric CO_2 from a round three parts per 10,000 to just under four. Most of the increase in the burning of fossil fuels has occurred over the last few decades and nine out of the ten warmest years ever recorded have occurred since 1990.[220]

In other words, it's the Baby Boomer (or 'war baby') generation that's really to blame because half of the energy generated since the Industrial Revolution has been consumed in the last twenty years.

Only it's not any single generation's fault – it's all of our faults in the developed world and, in the future, the culprit responsible for any further man-made climate change will be the looming and inescapable global population explosion.

The 20th Century opened to a world population of a little more than one billion people and closed on a world of six billion. Every one of those six

billion is using on average four times as much energy[221] as people did 100 years ago.

As I said in my introduction to this section, we are now confronted with the physical proof of climate change and Europe is a good place to go looking for extreme weather. Such extremes are caused by the atmosphere heating up. For every single degree Fahrenheit the atmosphere is warmed, world rainfall increases by 1 per cent. This does not sound like much, but the increase is very unevenly distributed.

A 1 per cent Fahrenheit rise in temperatures in the hottest parts of the world can have very serious effects. In early 2011 The Economist reported on the work of climatologist David Lobell, who has published a reported on the effects of temperature rises on the production of maize (or corn, as Americans call it) under the headline 'One Degree Over':

> Days above 30°C are particularly damaging (for maize production). In otherwise normal conditions, every day the temperature is over this threshold diminishes yields by at least 1%. Moreover, days where the temperature exceeds 32°C do twice the harm of those at 31°C. And during a drought, things are worse still. Then, yields take a hit of 1.7% per day over 30°C.
>
> This matters because increasing the average temperature only a bit can multiply the number of the hottest days a lot. The research predicts that a 1°C rise in average temperature will reduce yields across two-thirds of the maize-growing region of Africa, even in the absence of drought. Add drought and that effect spreads over the entire area[222].

The 1990s were the warmest decade in Britain since records began in the 1660s, with 2006 the hottest year ever, 2005 the second warmest year ever, 1998 the third warmest ever and 2001 the fourth warmest

In January 2007 The British Meteorological Office warned that 2007 would be the warmest year on record.[223] (and this turned out to be the case)). The trend towards extreme weather is starkly obvious – and it is being repeated across much of mainland Europe.

And in October 2007 The New York Times reported alarming news under a headline 'Arctic Melt Unnerves The Experts':

> The Arctic ice cap shrank so much this summer that waves briefly lapped along two long-imagined Arctic shipping routes, the Northwest Passage over Canada and the Northern Sea Route over Russia.
>
> Over all, the floating ice dwindled to an extent unparalleled in a century or more, by several estimates.
>
> Now the six-month dark season has returned to the North Pole. In the deepening chill, new ice is already spreading over vast stretches of the Arctic Ocean. Astonished by the summer's changes, scientists are studying the forces that exposed one million square miles of open water — six Californias — beyond the average since satellites started measurements in 1979.[224]

But in the years between the publication of the first edition of this book in 2007 and the revised 2011 edition, the science of climate change was briefly but damagingly discredited.

Just before the all-important meeting of global leaders in Copenhagen in December 2009, computer hackers of unknown origin hacked into the email

system of climate scientists at the University of East Anglia in the U.K. Selected emails that were then leaked anonymously to the media showed a scientific climate science fraternity that was uncooperative with the sceptical lobby and, even worse, not transparent about the evidence gathered on climate change.

The result was that those sections of the media politically opposed to leaders calling for strong action on climate disease used the shortcomings of the climate change scientists as a stick with which to beat their opponents (particularly the beleaguered Barrack Obama). Partly as a result of the doubts that were sown by this vicious and wicked campaign, the Copenhagen talks failed to agree to take any strong, concerted action to halt global warming (but, at the risk of repeating myself, it is also necessary to recall the devastating financial impact of the 2008 banking collapse on the international community).

Since 2009 it has become clear that the climate scientists at the University of East Anglia and elsewhere were not engaged in the fabrication, suppression or cover up of evidence about climate change (with the exception of one climate scientist who grossly overestimated the rate at which Himalayan glaciers are melting[225]). The worst that could be said about some members of this group was that they resented being constantly harassed by the lobbyists of the sceptical organizations and did not co-operate fully with their repeated requests for information.

But the science the climate scientists were doing was good, as the data from the last few years makes clear. After the publication of the first edition

of this book the year 2008 went on to became the tenth hottest year on record, 2009 became the second hottest year on record and 2010 became the hottest year ever measured.

In a 2010 report on satellite-measured global temperatures NASA researchers wrote[226]:

> Contrary to a popular misconception, the rate of warming has not declined. Global temperature is rising as fast in the past decade as in the prior 2 decades, despite year‐to‐year fluctuations associated with the El Niño‐La Niña cycle of tropical ocean temperature. Record high global 12 month running mean temperature for the period with instrumental data was reached in 2010.

The IPCC has specifically identified human activity over the last 250 years as the culprit for the atmospheric warming but new evidence now suggests that the problem started way before that. Emeritus Professor William F. Ruddiman[227] of the University of Virginia is a paleo-climatologist with over sixty years' experience. In his recent book 'Plows, Plagues and Petroleum'[228] he presents evidence from fossil records and ice/soil core samples that unnatural global warming began 12,000 years ago when Man first started growing crops and husbanding animals – the agricultural revolution.

Trees felled to make way for agriculture could no longer absorb CO_2 from the atmosphere and as landscapes were burned to create crop growing areas, more carbon dioxide was released. Then, as soil was turned over for planting and rice paddies were flooded, methane gas – a powerful climatic warming gas – was also released into the atmosphere. Growing herds of

husbanded animals bred for food and clothing also contributed by releasing methane gas produced by their own diets.

Of course, 12,000 years ago the number of humans on the planet was still very small – a few million at most – and the unnatural warming effect of their activities on the atmosphere was very slight indeed. But Professor Ruddiman and his colleagues were able to measure those subtle changes, changes that contradicted the expected cyclical change to which our planet's atmosphere is subject. So sensitive is our climate – and so accurate are the fossil records – that Ruddiman's team was also able to specifically plot the reduction in the output of man-made CO_2 and methane during the periods when plagues swept through Europe and Asia reducing human activity by as much as 50 per cent for a period of years.[v]

In the year 2030 historians may look back on the first decade of the 21st Century and identify it as the period in which humans missed a major opportunity to become serious about tackling climate change.

Touching On Some Less Well Known Causes of Climate Disease

Much has been written on the causes of climate change and I do not intend to describe in this section details about the number of new power stations being built in China every year, nor the USA's appetite for coal as a power-

[v] William Ruddiman pointedly states in the introduction to his book that he has received no funding from any individual, body or organisation which has an interest in proving the case about climate change either way.

generation resource. Suffice to say that the majority of human-produced (non-agricultural) carbon dioxide that enters the atmosphere is produced by electricity power generation and transport (road, rail, shipping and aviation).

Before examining some lesser known sectors that emit carbon – in particular aviation and shipping, two forms of transport that because of their international nature makes it convenient for domestic politicians to overlook them – it worth noting that China, in particular, is a rapidly emerging economy which clearly understands how critical it is to reduce carbon output even as it ramps up its power generation capacity.

In 2007 China's National Development and Reform Commission announced a $133.3 billion project to develop renewable energy sources[229]:

> China has released an ambitious plan to develop renewable energy to cut its surging carbon dioxide emissions.
>
> The 'Middle and Long-term Development Plan of Renewable Energies' promises to derive ten per cent of China's energy supply from renewables by 2010 and 15 per cent by 2020.

And in 2010 the New York Times reported[230]:

> China vaulted past competitors in Denmark, Germany, Spain and the United States last year to become the world's largest maker of wind turbines, and is poised to expand even further this year.
>
> China has also leapfrogged the West in the last two years to emerge as the world's largest manufacturer of solar panels. And the country is pushing equally hard to build nuclear reactors and the most efficient types of coal power plants.
>
> These efforts to dominate renewable energy technologies raise the prospect that the West may someday trade its dependence on oil from the Mideast for a reliance on solar panels, wind turbines and other gear manufactured in China.

And this commitment turned out to be fact. As The Guardian reported in 2010:

> China has overtaken the US for the first time in a league table of investments in low-carbon energy among the G-20, according to a new report by not for profit group the Pew Charitable Trusts published this week.
>
> The report found that despite an overall 6.6 per cent global decline in clean energy investments last year, China invested almost twice as much as the United States in clean energy during 2009[231].

Cleaning up power stations, finding renewable and sustainable sources of energy (see the following section on energy), conserving energy and sharply reducing our emissions from transport are all necessary and urgent actions. But there are also other factors to be considered.

As the paleo-climatologist Professor William Ruddiman points out, climate change began the moment humans started deforesting the planet and growing our food plants and husbanding our meat, instead of hunting and gathering. And deforestation is, itself, a major but under-appreciated source of global warming. The Independent reported in 2007:

> In the next 24 hours, deforestation will release as much CO_2 into the atmosphere as 8 million people flying from London to New York.
>
> Stopping the loggers is the fastest and cheapest solution to climate change. So why are global leaders turning a blind eye to this crisis? The rampant slashing and burning of tropical forests is second only to the energy sector as a source of greenhouse gases according to report published today by the Oxford-based Global Canopy Programme,[232] an alliance of leading rainforest scientists.
>
> Figures from the GCP, summarising the latest findings from the United Nations, and building on estimates contained in the Stern Report, show deforestation accounts for up to 25 per cent of global emissions of heat-

> trapping gases, while transport and industry account for 14 per cent each; and aviation makes up only 3 per cent of the total.[233]

And, what is done with the land once it has been deforested? Most is used for cattle husbandry. You may be surprised to learn that cattle themselves are responsible for producing 18 per cent of greenhouse gases, their noted flatulence leading pugnacious Ryanair boss Michael O'Leary to remark famously that governments 'should do something about cows farting'[234] rather than pick on his airline (although he has no reason to be smug; see the section on aviation below). According to the Christian Science Monitor:

> It's not just the well-known and frequently joked-about flatulence and manure of grass-chewing cattle that's the problem, according to a recent report by the Food and Agriculture Organization of the United Nations (FAO). Land-use changes, especially deforestation to expand pastures and to create arable land for feed crops, is a big part. So is the use of energy to produce fertilizers, to run the slaughterhouses and meat-processing plants, and to pump water.
>
> Livestock are responsible for 18 per cent of greenhouse-gas emissions as measured in carbon dioxide equivalent, reports the FAO. This includes 9 per cent of all CO_2 emissions, 37 per cent of methane, and 65 per cent of nitrous oxide. Altogether, that's more than the emissions caused by transportation.[235]

And we are not about to cut back on our cattle rearing, it seems. Despite my earlier reference to meat of the future being grown in factories (without a flatulent host animal) it seems that cattle-producing countries are confident about their future markets for beef. Under the headline 'Greater demand for cattle beef to come from developing nations' the Arab-Brazillian Chamber of Commerce reported:

> According to a sector study, by 2030 emerging countries will consume 350 million tonnes of cattle beef, against 100 million in developed countries. Brazil, which is already the greatest exporter in the sector, should occupy a special position in this market. 'The world needs

> Brazil to eat,' stated Abiec president, Marcus Vinícius Pratini de Moraes.[236]

Even the United Nations blames the cow. Under a headline that read, 'Cow "emissions" more damaging to planet than CO_2 from cars', The Independent reported**:**

> Meet the world's top destroyer of the environment. It is not the car, or the plane, or even George Bush: it is the cow.
>
> A United Nations report has identified the world's rapidly growing herds of cattle as the greatest threat to the climate, forests and wildlife. And they are blamed for a host of other environmental crimes, from acid rain to the introduction of alien species, from producing deserts to creating dead zones in the oceans, from poisoning rivers and drinking water to destroying coral reefs.[237]

What can be done? Well some California dairy farmers are turning manure into electricity.[238] Also, Australian scientists are working on isolating bacteria in Kangaroos[239] which allow them to eat grass and release no methane and British scientists claim to have already made a breakthrough in developing a low-methane diet for cattle.[240] The magic bacteria could hopefully be introduced into sheep, pigs, and cattle feed to reduce or eliminate methane release. And since more methane comes from garbage than from any other source, maybe we could find a way to harness that gas as a form of energy.

One good piece of news is that although methane is a potent greenhouse gas, it lingers in our atmosphere for only ten years (compared to 100 years or more for carbon dioxide) and thus any attempt to reduce methane emissions would produce effects that would be noticeable rapidly.

But even though cattle emissions has a comical quality, the notion of clearing more and more land on which to raise promiscuously flatulent cattle is not sustainable. There is no easy answer as the world must eat, but synthetic food (produced from chemicals), factory grown meat and even thoroughly tested and closely controlled genetically modified food plants (genetically modified organisms or GMOs) will have a role to play in some parts of the world.

This last observation is a matter of fact rather than prediction as the trend is very clear. Between 1996 and 2005, the total surface area of land cultivated with GMOs had increased by a factor of 50,[241] from 17,000 km² (4.2 million acres) to 900,000 km² (222 million acres), of which 55 per cent were in the United States.

Friends of the Earth point out that even if the environmental and human safety issues of GM crops could be satisfactorily answered (and that, they say, is a very big 'if') the switch from natural seeds and crops to GM seeds and crops would make the production of food the intellectual property of the large corporations which own the relevant patents. Food, which since the beginning of human existence has been a natural resource would, if the GM model were to prevail, become yet another product of big business. Such proprietorial development does not chime with the ambition for sustainable development and the effort to help the world's poorest people to help themselves to improve their lives. Friends of the Earth states:

> GM crops are not cheaper, are not better in quality and do not present any benefits for consumers. This is now even recognised by some parts of the biotech industry. After 30 years of research and public money,

> only two modifications are grown commercially to any extent: herbicide tolerance and insect resistance.[242]

On the other hand, the temptations of future GM bounty, especially the so-called 'third generation' genetically-modified 'pharma-crops', will seem very hard to resist. As SciDev.net explained:

> Growing pharmaceuticals and industrial products in plants through genetic engineering presents an important opportunity that Africa should grasp now.
>
> Such crops include plants engineered to produce biodegradable plastics, fibrous proteins, adhesives and synthetic proteins. For example, tobacco and potato plants have been engineered to produce spider silks.
>
> 'Pharmacrops' are plants genetically modified to produce pharmaceuticals, for example vaccines, antibodies and proteins to treat human or animal diseases. Maize engineered to express human gastric lipase, used to treat cystic fibrosis, is already in advanced clinical trials.[243]

What is unarguable, however, is that given the problem of continuing deforestation, the world's populations must be educated to reduce the amount of meat in their diets. Meat is about the least land-efficient and energy-efficient way of transferring protein/energy from our environment into our bodies (although the fastest method of energy ingestion at the point of consumption). And a reduced meat diet would improve the health of most citizens.

As Jeremy Rifkin explains in 'The Hydrogen Economy':

> One third of the world's agricultural land has been converted from growing food grains for human consumption to growing feed grain for cattle and other livestock. Cattle production is now the most energy-consuming agricultural activity in the world. It takes the equivalent of a gallon of gasoline to produce a pound of grain-fed beef in the US To sustain the yearly beef requirements of an average family of four people requires the consumption of more than 260 gallons of fossil fuel. When

> that fuel is burned, it releases 2.5 tons of additional CO_2 into the atmosphere – as much CO_2 as the average car emits in six months of normal operation.

Shipping

Shipping is a transport sector producing significant greenhouse gas emissions but one which is rarely discussed (and one which is often omitted from domestic climate change recommendations and legislation). But it must be pointed out that in terms of moving bulk cargo around the world, the emissions emitted per ton from shipping are the lowest of all forms of transport. This does not mean, however, that the shipping industry can ignore the need to curb its emissions.

Although relatively small, shipping was the fastest growing of all transport sectors before the recent recession. According to The Economist in 2007:

> World merchandise trade (shipping) is growing at 15 per cent a year. Trade between China, India, America and Europe accounts for 65 per cent of the 250m-plus containers moved around the world each year. Freight rates rose by nearly one-third in the four years to the peak of the cycle in the third quarter of 2005. That led to a splurge in orders for new, larger ships.[244]

The financial crisis of 2008 caused a slump in shipping in 2009 and the first half of 2010 but in February 2011 the giant Danish shipping conglomerate Maersk announced a return to profitability and growth in shipping movements once again[245].

Perhaps one of the best places in the world to witness for yourself the impact of ships' greenhouse gas emissions is Istanbul. The beautiful old city

sits either side of the narrowest shipping lane in the world, the Bosphorus, a strait which links the almost completely enclosed Black sea to the Aegean Sea and the Mediterranean beyond.

For all of the rapidly developing countries around the Black Sea – Bulgaria, Romania, the Ukraine, Georgia, and Northern Turkey itself – the Bosphorus (which at places is only 700 metres wide) offers the only access channel for tankers and container ships. Every ten minutes huge cargo vessels pass in each direction, piloted by local watermen and controlled by a marine equivalent of an air traffic control system. All of them belch out large quantities of CO_2, SO_x[246] and NO_x[247].

Istanbul already has a serious pollution crisis as its twelve million inhabitants attempt to get around their vast city. The transport infrastructure is poor because of a difficult topography, earthquake risk and chronic long-term under-investment. There is almost no metro system and the ancient ferry boats which criss-cross the Bosphorus add their noxious outpourings to those of millions of cars and the giant cargo vessels and cruise liners which sail through the strait.

As a result of all this shipping and heavily-jammed road transportation beautiful Istanbul is choking to death inside a foul brown miasma which contributes heavily to the region's high carbon output and to appalling public health and Turkish mortality figures.[248]

However, some technological breakthroughs are occurring which are allowing new ships to run far more cleanly. Interestingly, these developments are being made in the region responsible for most of the

growth in global shipping. A news story published in China makes the following claims:

> China has made substantial breakthroughs in shipbuilding as the first liquefied natural gas (LNG) ship made in China, one of the most advanced in the world, will be delivered in September.
>
> The boat with a capacity of 47,200 cubic meters is under construction by the Hudong-Zhonghua Shipbuilding, a subsidiary of the China State Shipbuilding Corporation (CSSC), China's top and the world's third largest shipping group.
>
> Another four such LNG vessels also under construction would be delivered in the end of this year while the research and development for LNG ships with a capacity of 200,000 cubic meters is underway.[249]

And sail power may even make a come-back both to save shipping fuel and to reduce carbon emissions, The German company Sky Sails[250] is now marketing giant 'kite-style' sails for large ships to use during their long ocean crossings. The company claims:

> By using the SkySails-System, a ship's fuel costs can be reduced by 10-35 per cent on annual average, depending on wind conditions. Under optimal wind conditions, fuel consumption can temporarily be reduced by up to 50 per cent. Even on a small, 87 metre cargo ship, savings of up to 280,000 euros can be made annually.
>
> In 2007 the first SkySails-Systems with towing-kite areas of up to 320 m² for cargo vessels, superyachts and fish trawlers will be available. Series production will start in 2008.[251]

And finally, to end this very incomplete survey of shipping emissions, don't even consider thinking about using passenger liners for travel, or even of taking a luxury cruise. In his influential book 'Heat, How To Stop The Planet Burning,' British environmental campaigner George Monbiot publishes his calculation about how much carbon is produced by the cruise liner Queen Elizabeth II on behalf of each of its passengers.

> Cunard says the ship burns 433 tonnes of fuel a day, and takes six days to travel from Southampton to New York. If the ship is full, every passenger with a return ticket consumes 2.9 tonnes. A tonne of shipping fuel contains 0.85 tonnes of carbon, which produces 3.1 tonnes of carbon dioxide when it is burnt. Every passenger is responsible for 9.1 tonnes of emissions. Travelling to New York and back on the QEII, in other words, uses almost 7.6 times as much carbon as making the same journey by plane.[252]

But there is one way in which you can cross the Atlantic by sea without being responsible for emitting a single atom of carbon – ask for a ride on a solar-powered motorized catamaran called Sun21. As Gizmag.com reported:

> In a giant leap towards unfuelled travel, a full-sized motorised catamaran, the 'Sun21,' has just completed a leisurely crossing of the Atlantic ocean without consuming a drop of fuel. Stored solar energy powered the 5-man crew from Spain to the USA at a constant rate of 5-6 knots around the clock via electric engines. This is a major achievement - a reliable, long-distance, powered vehicle with zero fuel costs - and its successful journey hints at a cleaner, greener, cheaper future of transport.[253]

Aviation

And now we come to a very difficult topic; aviation. Jet travel is a mode of transport that has such serious potential as a contributor to climate change that it deserves its own section – especially because international aviation, like shipping, is often conveniently excluded from domestic thinking and policy making on climate change because most gasses are emitted in international territory, rather than in national air space.

Although carbon emissions from jet aircraft currently amount to only 2-3 per cent of all global CO_2 emissions (about 12% of emissions generated by all forms of transport), aviation is a transport sector that is still growing very rapidly (but unevenly) and emissions from aircraft seem to have a greater detrimental impact on the atmosphere than other forms of carbon emission.

Although aviation growth in Europe and the U.S.A. is not rapid, growth in the developing world is considerable, as the China Daily reported in 2009:

> Airbus SAS, the world's largest maker of commercial aircraft, said in a report that China's aviation market will see an annual increase of 7.9 percent in the next 20 years, following India to become the world's second fastest growing market.
>
> India's aviation market is forecast to have a 10 percent growth annually over the next two decades, according to the report.
>
> A total of 25,000 new planes worth $3.1 trillion will be delivered between 2009 and 2028 in the global airline market, said the report[254].

And by 2014 the number of plane journeys made by individual passengers around the world is expected to reach 3.3 billion (up from 2.5 billion in 2009)[255]. In part, this is a consequence of the falling cost of flying: ticket prices have dropped by 60%, in real terms, over the past 40 years.

In 2011 Airbus (the large European plane maker) predicted how many new planes will be built and purchased over the next 20 years. As Quality Manufacturing magazine reported:

> Over the next 20 years nearly 26,000 new passenger and freighter planes will be needed according to aircraft company Airbus. The world's passenger fleet amounts to more than 14,000 planes at the moment and this figure is expected to rise to 29,000 by 2029, representing a value of around £1,880 billion.

> The company's forecast is 900 planes higher than its long-term prediction made at the end of 2009.
>
> 10,000 of the new planes will replace older and "less-green" aircraft.. The other 15,000 will be to accommodate passenger growth, said Airbus .

In ‘Heat’, George Monbiot has a great deal to say about jet travel:

> Aviation has been growing faster than any other source of greenhouse gases. Between 1990 and 2004, the number of people using airports in the United Kingdom rose by 120 per cent, and the energy the planes consumed increased by 79 per cent.[256] Their carbon dioxide emissions almost doubled in that period – from 20.1 to 39.5 million tones, or 5.5 per cent of all the emission this country produces.
>
> Unless something is done to stop this growth, aviation will overwhelm all the cuts we manage to make elsewhere. The government predicts that, ‘if sufficient capacity were provided’, the number of passengers passing through airports in the United Kingdom will rise from roughly 200 million today to ‘between 400 million and 600 million’ in 2030. It intends to ensure that this prophecy comes to pass. The new runways it is planning ‘would permit around 470 million passengers by 2030’. [257]

Friends of the Earth[258] and the Co-operative Bank commissioned the Tyndall Centre For Climate Change[259] Research in Manchester UK to produce a report called ‘Living Within A Carbon Budget’ which made an excellent attempt to lay out a road map for how Britain could achieve the cuts in carbon emissions necessary to meet the targets necessary to escape the worst effects of climate change. On the topic of aviation the report was particularly fierce:

> The scale of carbon emissions from aviation allied with very high annual growth in the industry and the limited opportunity for efficiency improvements should place aviation at the forefront of the climate change agenda.
>
> Despite this, Government is reluctant to actively curtail the rise in aviation emissions, when self evidently the associated emissions profile cannot be reconciled with the Government’s existing 60 per cent

> emission reduction target, and completely undermines any chance of achieving the more stringent targets that increasingly scientists connect with the 2°C threshold. The long-term repercussions of such an approach are difficult to overstate.
>
> In relation to propulsion, jet engines are a mature technology, and consequently the efficiency of the current fleet is not set to change substantially within the foreseeable future. Exacerbating this absence of a step-change in fuel efficiency is the long design life of aircraft, effectively locking society into current technology for at least the next 30-50 years.[260]

And carbon emissions from aircraft do seem to be particularly harmful to our atmosphere. In 'Heat' George Monbiot explains:

> The climate impact of aeroplanes is not confined to the carbon they produce. They release several different kinds of gases and particles. Some of them cool the planet, others warm it.
>
> The overall impact, according to the Intergovernmental Panel on Climate Change, is a warming effect 2.7 times that of the carbon dioxide alone. This is mostly the result of the mixing of hot wet air from the jet engine exhaust with the cold air in the upper troposphere, where most large planes fly. As the moisture condenses it can form condensation trails which in turn appear to give rise to cirrus clouds – those high wispy formations of ice crystals known as 'horsetails.'
>
> While they reflect some of the sun's heat back into space, they also trap heat in the atmosphere, especially at night. The heat trapping seems to be the stronger effect[261]. [262]

The fact that jet contrails reflect 'some of the sun up' does cause confusion within the community of concerned environmental writers. In 'The Weather Makers' Tim Flannery writes:

> Air travel is currently growing at between 3 and 5 per cent per year and cargo transportation by air is increasing by 7 per cent per year. The researchers at Imperial College London[263] are combining predictions from climate change models with air traffic simulations to predict contrail formation and identify ways of reducing it.
>
> But the above researchers' assumption about clouds formed by contrails heating up the atmosphere may be wrong. Some climate scientists have

> theorised that aircraft contrails[264] (also called *vapour trails*) are implicated in global dimming,[265] but the constant flow of air traffic previously meant that this could not be tested.
>
> The near-total shutdown of civil air traffic during the three days following the September 11, 2001 attacks afforded a rare opportunity in which to observe the climate of the United States absent from the effect of contrails. During this period, an increase in diurnal temperature variation of over 1 °C was observed in some parts of the US, i.e. aircraft contrails may have been raising nighttime temperatures and/or lowering daytime temperatures by much more than previously thought.
>
> In other words, global dimming may be masking the effect of global warming but, in doing so, is slowing down its worst effects. Scientists are not agreed on this subject.[266]

In the end, most environmentalists come to the conclusion that the growing world population must *reduce* its use of air transport, rather than allowing it to grow vigorously as is predicted. However, I fear that unless high carbon taxes or even legislation limiting air travel is introduced (something that would be very difficult to achieve on international routes) the business community and the general public will continue to increase its demand for aviation.

However, relatively little media attention is being paid to possible alternative fuels for jet engines. It has been received wisdom that jet engines require from their fuels such a high density of energy to their weight (and the ability to remain liquid at the very low temperatures of stratospheric travel) that there is no practical alternative to carbon-dense kerosene.

Even the Intergovernmental Panel on Climate Change is certain that there is no alternative to kerosene for jet fuel. In its report Aviation and the Global Atmosphere, the panel says**:**

> There would not appear to be any practical alternatives to kerosene-based fuels for commercial jet aircraft for the next several decades. Reducing sulfur content of kerosene will reduce SO_x emissions and sulfate particle formation.
>
> Jet aircraft require fuel with a high energy density, especially for long-haul flights. Other fuel options, such as hydrogen, may be viable in the long term, but would require new aircraft designs and new infrastructure for supply.[267]

Despite such apparent authoritative certainty about the bleak future for aviation emissions, Time Magazine reported in 1988 that the Soviet Union had successfully converted a Tupolev Tu-154 passenger jet modified to burn a mixture of liquid hydrogen and natural gas[268].

To be fair to the Tyndall Centre the authors of 'Living Within A Carbon Budget' did recognize that bio-fuels must play an important role in aviation:

> In addition to the demand management and fuel efficiency improvements therefore, a third of aviation fuel must come from low-carbon, technologically compatible sources such as bio-diesel and bio-kerosene to ensure that the industry meets its carbon obligations.[269]

British transport mogul (and self-interested airline boss) Sir Richard Branson also thinks there is a future for cleaner biofuels in jet aviation. Writing about Virgin Atlantic, the airline Sir Richard heads, The Independent newspaper reported in 2007:

> Virgin Atlantic will also announce today that it is to become the first carrier in the world to use green aviation fuel. Virgin Atlantic is planning to launch trials next year with Boeing and the US engine manufacturer General Electric, flying a 747 aircraft using a mixture of bio-fuel and conventional aviation fuel.[270]

Since 2007 many other airlines have carried out tests using biofuels on one or more engines on multi-engined jet planes including Lufthansa,

Continental and Japan airlines. And in early 2011 the U.S. Navy tested a biofuel blend on the F⁄A-18 Super Hornet aka 'Green Hornet' jet fighter. Results from those tests indicated the aircraft performed as expected through its full flight envelope with no degradation of capability.

And, as the website gizmag.com reported in Spring 2011 the U.S. Navy continues its tests with biofuels:

> The U.S. Air Force's goal of acquiring 50 percent of its domestic aviation fuel via alternative fuel blends derived from domestic sources by 2016 got a boost on Friday March 18, when an F-22 Raptor was successfully flown at speeds of up to Mach 1.5 on a 50/50 fuel blend of conventional petroleum-based JP-8 (Jet Propellant 8) and biofuel derived from an inedible plant called camelina. The flight capped off a series of ground and flight tests carried out earlier in the week for the Raptor using the biofuel blend to evaluate its suitability in the F-22 weapons system[271].

Virgin Atlantic is also upgrading its fleet of aircraft to include 15 Boeing 787 Dreamliners,[272] which are claimed to burn 27 per cent less fuel than other comparably sized twin-engine jets. Boeing claims the 787 uses less fuel, largely because it is made with composites and metals and weighs less than standard aluminium-frame airplanes.

Of the much more fuel economical Boeing 787, The Economist reported in 2007 under the headline 'Travelling green tonight'**:**

> With half its primary structure, including the fuselage and wings, made from composites, the 787 is much lighter than any metal aircraft of similar size. That not only saves fuel but allows other improvements. For example, the air is nicer to breathe. Airliners have to be pressurised when flying above 10,000 feet because oxygen levels drop dangerously low. At cruising height, usually around 35,000 feet, cabin pressure in most aircraft is kept at the equivalent of around 8,200 feet (about the

> same as Mexico City) because maintaining a higher pressure in a conventional aircraft might accelerate metal fatigue. To add to passengers' discomfort, the air is kept as dry as possible because moisture causes metal to corrode. But the 787 is pressurised at the equivalent of 6,000 feet and the air can be kept less dry because the composites are stronger than metal and unaffected by moisture.[273]

But since the first edition of this book was published repeated delays to the production schedule of the Boeing 787 have postponed any benefits the cleaner aircraft might have brought. Originally due to enter service in May 2008, the Dreamliner did not begin flying commercially until late 2011 and, because of the delay, older, dirtier planes have been forced to continue polluting the skies.

But biofuels do hold out some promise. Producing biofuel for jet engines would not have the vast and potentially disastrous environmental impact that switching to biofuels such as ethanol for road transport would have (see my later section 'The Future of Energy'). Even the enlarged jet fleets of the future would only use a tiny fraction of the fuel consumed by the world's millions of road vehicles and aviation's potential for harmful carbon emissions is so great that a good case for switching to biofuels can be easily made.

But even though the development of green biofuels points to a future in which jet travel is no longer a significant polluter (certainly by 2030) it will be years before biofuels can be thoroughly tested and production ramped up to the necessary levels. In the meantime, what can we do?

Carbon offsetting schemes[274] vary in quality and efficiency and even the best of such schemes cannot be safely regarded as true mitigators of the damage caused by aviation. In essence, carbon offset schemes enable us to

make a payment to an organization who then undertakes to plant trees or to invest in energy saving projects in order to reduce CO_2 emissions elsewhere in the world, at some time in the future, to a degree that roughly equals the carbon that you as an airline passenger have been responsible for emitting.

In The Guardian environmentalist George Monbiot made his position regarding carbon offsets clear:

> Any scheme that persuades us we can carry on polluting delays the point at which we grasp the nettle of climate change and accept that our lives have to change. But we cannot afford to delay. The big cuts have to be made now, and the longer we leave it, the harder it will be to prevent runaway climate change from taking place. By selling us a clean conscience, the offset companies are undermining the necessary political battle to tackle climate change at home. They are telling us we don't need to be citizens; we need only to be better consumers.
>
> Yet aviation emissions, to give one example, are rising so fast in the UK that before 2020 they will account for the country's entire sustainable carbon allocation. A couple of decades after that, global aircraft emissions will match the sustainable carbon level for all economic sectors, across the entire planet.[275]

Tony Juniper, director of Friends of the Earth, said in January 2007:

> 'Carbon offsetting schemes are being used as a smokescreen to avoid real measures to tackle climate change. We urgently need to cut our emissions, but offsetting schemes encourage individuals, businesses and governments to avoid action and carry on polluting. There is still time to act, but we cannot afford to be distracted by measures that at best only have a small role to play in providing the solutions to global warming.'[276]

So, if biofuels are years away and carbon offsetting schemes offer no solution what else must we do about aviation? Completely redesigning aircraft is one possible answer. In 2007 Gizmag.com reported:

> The standard aircraft design with which we have all become so familiar throughout the 20th century is headed for the scrap heap. Despite its ubiquitous nature, the traditional shape is set to be superseded in the

> push towards cleaner, greener aircraft that can transport people around the globe using less and less fuel.
>
> Now a new research group at a Netherlands university has been formed with the explicit goal of consigning the current shape of passenger airliners to the history books. The CleanEra project will investigate BWB (blended-wing-body), high-tech propeller engines and even UFO-style body shapes in their efforts to produce a light, efficient airliner model that produces less noise and cuts carbon dioxide emissions by at least 50% over current designs.[277]

But completely new aircraft will take many years to design, test and build and, in the meantime, something must be done urgently to reduce emissions produced by aviation.

The simple fact is that if we are to meet the IPCC's emissions reductions targets, carbon has to be taxed at the point where it is emitted (i.e. taxing the airlines as they fly). The money raised must be used to undertake very large scale tree planting (an excellent low-tech way of combating climate change – especially as young, rapidly growing forests absorb far more CO_2 than mature forests) and to hasten the development of biofuels (where appropriate) and the development of renewable and sustainable clean energy sources.

Strong carbon taxation will slow aviation's return to growth (as recent tax hikes on UK aviation[278] is proving) and those of us who bought second homes abroad (not me) because of cheap airline fares will, unfortunately, feel some pain (quite apart from any pain that may be suffered by the property crashes experienced in Spain, Greece, Ireland, etc.). Business travel may be reduced (or at least, not grow so quickly) and some cargo may transfer to the shipping lanes. There is no alternative.

What We Must Do About Climate Change

There are as many prescriptions for saving the planet as there are concerned 'environmentalists' and the challenge is so vast, so important, that transparent and hidden political agendas invariably shape many of the proposals.

Given that we must face this serious and very dangerous global crisis in the 21st Century, it is clear that something has to be done. 'Business as usual' simply isn't an option.

The California Progress Report, published in early 2007, came to a stark conclusion:

> In effect, the battle is already lost. The globe will continue the warming trend that began in the middle of the last century. More frequent heat waves, stronger storms, more devastating droughts, rapidly melting glaciers, and rising sea levels are coming our way no matter what we do. The question the report asks is whether we have the will to change our behavior quickly enough to prevent this bad news from becoming horrific. Even if we somehow stopped all greenhouse gas emissions immediately, global temperatures would still rise 1.1ºF by century's end. That would mean shutting down every plant, automobile, or device that runs on oil, coal, or natural gas today, while also stopping all rainforest destruction—an impossibility surely. The IPCC report says we can only afford another 2.5ºF rise before the weather changes would become catastrophic. To decarbonize our economies quickly enough to slip below that threshold, scientists say we would need to cut emissions by 80 per cent by 2050.[279]

How difficult will it be to cut emissions by 80 per cent by the year 2050? Well, given the right mind set, I think we can achieve this target without causing major damage to the global economy and the expectations of the

millions in the world's rapidly emerging territories such as China, India and parts of Latin America.

The Right Mind Set

Even though some symptoms of climate change cannot, now, be avoided and even though there is currently no global consensus on how to tackle global warming, our principal task in the 21st Century must be to work to mitigate the worst effects that climate disease could bring and to avoid the human deaths, the misery and the huge costs that would follow in their wake.

To do this, we need to change minds and lifestyles around the planet. If this sounds like a tall order, I would disagree. I have been speaking and writing about the effects of climate change since the early 1990s (very recently by some standards) and I have seen a shift in public attitudes in Europe which can only be described as extremely heartening. According to a 2006 Financial Times opinion poll:

> Europeans are overwhelmingly convinced that human activity is contributing to global warming, and a majority would be prepared to accept restrictions on their lifestyle to combat it, according to a poll for the Financial Times.
>
> Research carried out this month by Harris Interactive in Germany, France, the UK, Italy and Spain found that 86 per cent of people believed humans were contributing to climate change, and 45 per cent thought it would be a threat to them and their families within their lifetimes.[280]

Then, in late June 2007, The Independent reported:

> There has been a double-digit increase in the proportion of Americans who say environmental problems are a major global threat - from 23 per

> cent to 37 per cent, according to a comprehensive survey published this week by the Pew Centre in Washington.
>
> The environment is increasingly in the news in the US, thanks to violent and unusual weather patterns - mainly floods and severe drought - combined with the rising cost of petrol. The past few days have seen dramatic rainfall across the southern states. More than a foot of rain fell across central Texas and Oklahoma yesterday, with more storms predicted.
>
> The survey found that the Chinese are far more likely than Americans to cite environmental problems as a major global danger (70 per cent against 37 per cent).
>
> Worldwide, most people in the surveyed countries agree that the environment is in trouble and most blame the US and, to a much more limited degree, China.[281]

To bring this section on public opinion about climate change more up to date, it is interesting to report on a world-wide poll of public attitudes towards the subject which was published by the polling organization Gallup in 2008:

> A 2007–2008 Gallup Poll surveyed individuals in 128 countries. This poll queried whether the respondent knew of global warming and, for those who were aware of the issue, whether or not they thought it was human-induced.
>
> Over a third of the world's population were unaware of global warming, with developing countries less aware than developed, and Africa the least aware.
>
> Of those aware, residents of Latin America and developed countries in Asia lead the belief that climate change is a result of human activities while Africa, parts of Asia and the Middle East, and a few countries from the Former Soviet Union lead in the opposite. Opinion within the United States and the United Kingdom is divided.
>
> Adults in Asia, with the exception of those in developed countries, are the least likely to perceive global warming as a threat. In the western world, individuals are the most likely to be aware and perceive it as a

> very or somewhat serious threat to themselves and their families although Europeans are more concerned about climate change than those in the United States.
>
> However, the public in Africa, where individuals are the most vulnerable to global warming while producing the least carbon dioxide, is the least aware-which likewise translates to a low perception that it is a threat[282].

So there remains clear public alarm about global warming (in the most of the developed world, at least), but the fickleness of public opinion, and the woeful lack of public understanding about the topic, was revealed in 2011 when the British Office for National Statistics produced a poll that showed the number of British climate change sceptics has doubled since 2006. The Daily Mail (itself more than a little sceptical) gleefully reported:

> The number of climate change sceptics has almost doubled in four years, official research showed yesterday.
>
> A quarter of Britons are unconvinced that the world is warming following successive freezing winters and a series of scandals over the credibility of climate science.
>
> The figures suggest that a growing proportion of the public do not share the belief of all three major political parties and Whitehall – that climate change is a major and urgent challenge requiring radical and expensive policies.
>
> The survey, carried out by the Office for National Statistics, has plotted levels of acceptance of the theory of man-made global warming since 2006.
>
> In that year it found that 87 per cent of people were at least 'fairly convinced' that climate change was happening.[283]

Britain had suffered two particularly severe winters in 2009 and 2010 and the research behind the poll suggested that the general public took this as

evidence that global warming wasn't a problem without realizing that the local symptom of a heated atmosphere is more extreme weather, rather then a general rise in temperatures.

What we need now is effective and closely policed legislation from our politicians; legislation that doesn't only set targets for the reduction of our carbon emissions, but which offers incentives and inducements for businesses and individuals to help meet them. Distressingly, there is no sign of such leadership emerging amongst the world's politicians at the time of writing.

I know that climate disease will force its way back to the top of all political agendas over the next few years because the incidence of extreme weather experienced around the world is increasing sharply. As the IPCC said in its 2007 report:

> Since 1950, the number of heat waves has increased and widespread increases have occurred in the numbers of warm nights. The extent of regions affected by droughts has also increased as precipitation over land has marginally decreased while evaporation has increased due to warmer conditions. Generally, numbers of heavy daily precipitation events that lead to flooding have increased, but not everywhere. Tropical storm and hurricane frequencies vary considerably from year to year, but evidence suggests substantial increases in intensity and duration since the 1970s.In the extratropics, variations in tracks and intensity of storms reflect variations in major features of the atmospheric circulation, such as the North Atlantic Oscillation[284].

Handily, in March 2011 the World Meteorological Organization summed up the extreme weather events the world has experienced since the 2007 edition of this book was published:

> **2008**: China witnessed the worst severe winter weather in five decades in January, with over 78 million people affected by the freezing temperatures and heavy snow. The exceptional cold extended westwards across Asia as far as Turkey. There was an unusually mild winter over most parts of Scandinavia; with monthly anomalies exceeding 7°C for much of Norway, Sweden and Finland, it was the warmest winter ever recorded. Tropical Cyclone *Nargis* with maximum winds of 215 km/hour was the most devastating cyclone to strike Asia since 1991, causing Myanmar's worst natural disaster ever. Heavy rain and flooding in Brazil in November affected 1.5 million people and resulted in 84 fatalities. Severe prolonged drought hit rgentina,Uruguay and Paraguay, where large areas reported one of the driest years on record.
>
> **2009:** Australia was marked by exceptional heatwaves, which affected the south-eastern part of the country in January/February. This was associated with disastrous bushfires that caused more than 170 fatalities. Victoria recorded its highest temperature with 48.8°C at Hopetoun, the highest temperature ever recorded so far south in the world.
>
> **2010:** The year 2010 ranked as the warmest year on record, along with 1998 and 2005. (The difference in global surface temperature between the three warmest years 1998, 2005 and 2010 is within a small range of 0.02°C, making the difference statistically indistinguishable.) The 2009/2010 winter was characterized by extremely cold temperatures over large parts of the northern hemisphere, including parts of Europe, Asia and North America.
>
> Hundreds of records for daily minimum temperatures were broken in the United States. Heavy snowfall disrupted air and road traffic in Europe, the United States and China. By contrast there were very mild conditions over the Arctic and Canada. These conditions were associated with large-scale atmospheric disturbances connected to the Arctic and North Atlantic Oscillations and the El Niño event.
>
> The summer of 2010 witnessed a sequence of devastating extreme events, frequently associated with unprecedented impacts. Over the course of the 2010 monsoon season, Pakistan experienced the worst floods in its history. Heavy rainfall, flash floods and riverine floods combined to create a moving body of water equal in dimension to the

> land mass of the United Kingdom. The floods affected 84 of 121 districts in Pakistan, and more than 20 million people – one-tenth of Pakistan's population – devastating villages from the Himalayas to the Arabian Sea. More than 1 700 people were killed, and at least 1.8 million homes damaged or destroyed.
>
> July 2010 was the warmest month ever in Moscow since the beginning of modern meteorological records. Temperature exceeded the long-term average by 7.8°C (the previous record in July 1938 was 5.3°C above average). More than 20 daily temperature records were broken, including the absolute maximum temperature in Moscow. The high temperatures which extended from July to the first half of August triggered massive forest and peat fires in the European part of the country, with smoke and smog adversely affecting tens of millions of people.
>
> The devastating heatwave in the Russian Federation and floods in Pakistan were associated with a "blocking event" in the northern hemisphere jet stream, which kept weather patterns stationary over certain countries. La Niña conditions, which prevailed during summer 2010 and subsequently, have been associated historically with increased likelihood of wetter-than-average conditions over the Indian subcontinent.
>
> In many parts of China, high temperatures broke historical extremes. Floods, landslides and mud-rock
> flows also caused serious economic damage. In August, Zhouqu County, Gansu Province, was hit by the most devastating flood and mud-rock flow in the country's history of the China, killing more than 1 500 people[285].

No single example of extreme weather can be attributed to climate disease but, taken together, we are already receiving a taste of what lies in store for us over the next 30 years. The list in the previous paragraph speaks for itself.

It is clear that governments must act now..

But, as individuals, we too have to change our way of thinking about how we use the resources of the planet. And the one thing that causes change in a personal lifestyle is EDUCATION.

By ‘education’ I don’t mean a series of television ads exhorting the populace to save energy (although that might help), I mean continuing education by the media, by governments, by businesses and NGOs and by industry to make the public more and more aware of its responsibility to our planet. In essence, we all have to develop a conscience (and a consciousness) about the cost of our lifestyles.

Energy (by which I mean transport fuel, electricity and gas) has been so relatively cheap in the developed world that most of us have used it with an uncaring, rapacious profligacy that will seem shocking to future generations.

A visitor to the United States who witnesses that nation’s absolute reliance on automobiles might conclude that nothing can be changed in US domestic policy without completely dismantling a society that has become wholly addicted to cheap energy (which is why, perhaps, so many American citizens are pig-headed about refusing to accept that climate change is a serious problem). And I understand that in societies and communities that were designed *after* the automobile was invented a legislative prescription to restrict citizens using such transport would be doomed to fail.

The answer has to be redesign vehicles to be far more frugal with energy, to change the nature of the fuels they use and to develop rapidly renewable and sustainable sources of energy. There are encouraging signs that the world is listening, and that automakers are responding properly. In Spring 2011 the British magazine The Engineer reported:

> Luxury car manufacturers firmly staked their claim in the green automotive sector yesterday by unveiling a slew of high-end battery and hybrid electric vehicles at the Geneva Motor Show.
>
> BMW, Land Rover and Rolls-Royce all showed off their latest alternative-powertrain concept cars, while Nissan premiered a fully electric sports car that can achieve 0 to 100km/h in less than five seconds.
>
> While none of the cars are scheduled to go on sale yet, their design marks a shift towards the mainstream for electric vehicles. No longer is battery power associated with cramped commuter cans or wildly designed playthings. These are powerful and fast machines that, importantly, look like the high-end cars already on our roads[286].

'The right mind set' means that we each have to become conscious of the cost of our actions in our daily lives. If, magically, all of us in the developed world lived our lives in a way that acknowledged the environmental cost of our lifestyle, the targets for emissions cuts would be far more easily met.

Do you ensure that the electrical devices in your home do not waste energy idling in 'standby' mode (7 per cent of electricity consumed in the UK goes to feed devices on 'standby[287])? Do you walk, cycle or take public transport as often as possible and eschew the use of a car unless absolutely necessary? When you are forced to use a car do you ensure that it has the lowest carbon emissions possible (or do you drive a 4X4 in a city)? This is what the 2007 IPCC report on what we must do about climate change had to say on transport:

> Unless there is a major shift away from current patterns of energy use, projections foresee a continued growth in world transportation energy use by 2 per cent per year, with energy use and carbon emissions about 80 per cent above 2002 levels by 2030.[288]

Do you take the time to separate your waste and recycle items which have energy stored within them or which can be recycled to save the use of virgin

resources? Have you replaced your wasteful incandescent electric light bulbs with energy-saving bulbs? You should – here's what the magazine New Scientist wrote on the subject in early 2007:

> Western governments are gunning for the humble light bulb because it wastes huge amounts of energy. First to propose calling time was the state of California: on 31 January it unveiled the 'How Many Legislators Does it Take to Change a Light Bulb Act', which, if passed, will ban the bulbs by 2012. Three weeks later, Australia announced a plan to do likewise. This month the UK government promised to phase them out by 2011.[289]

Of course many people have aesthetic objections to today's energy-efficient light bulbs. But new LED-based lights are arriving to widen the range of alternatives to the standard 100-year-old incandescent bulb.

Have you honestly worked to make your home as energy-efficient as possible? In 'Heat', George Monbiot makes the following observation about British energy efficiency compared to other countries in Europe:

> Houses which meet the building codes in Norway and Sweden use around one quarter of the energy of houses meeting the standards in England and Wales. In fact, the building regulations in Sweden were tougher in 1978 than they are in Britain today. In Germany the air tightness standard – which determines how leaky a house is allowed to be – is three times as stringent as the standard in Britain. The 'Passivhaus' (passive house with zero carbon emissions) was first developed in Germany in the late 1980s.
>
> There is nothing magical about these constructions, and they rely on little in the way of innovative technology. The builders need only ensure that the 'envelope' of the house – the bit that keeps weather out – is as airtight as possible and contains no 'thermal bridges'. A thermal bridge is a material that conducts heat easily from the inside of the house to the outside. At every point – even where the wall meet the ground or the roof – contact with outside temperatures must be interrupted with insulating materials.[290]

Governments are, of course, moving rapidly to introduce legislation which lays down energy efficiency standards for new home construction and in Germany legislators are preparing to introduce an 'Energy Passport'[291] which will guarantee the energy efficiency of private homes. In the UK the government introduced Home Information Packs[292] which forced property sellers to include an energy efficiency audit of their homes for the benefit of prospective buyers, only for the newly elected coalition government to suspend the use of such packs in May 2010. They are unlikely to be reintroduced in the life of the present government.

But legislation and good intentions on their own are not enough (even when they're enforced). In 'Heat', George Monbiot cites the Energy Savings Trust and Energy Efficiency Partnership for Homes who say that a large percentage of new buildings constructed in the UK do not meet the energy efficiency ratings required by law:

> A study by the Buildings Research Establishment found that 43 per cent of the new buildings it tested, which had received certificates saying that they complied with the regulations, should have been failed.
>
> Professor David Strong, the head of the Establishment, observes that plenty of new homes have the requisite amount of insulation in their lofts, but quite often it is still tied up in bales, as the builders, knowing that no one would be checking, couldn't be bothered to roll it out.[293]
>
> One of the reasons for this is that the government has allowed builders to turn to the private sector to get their certificates.[294]

Independently, The New Scientist reported on findings that seem to bear out these allegations:

> Last year, when the UK's Building Research Establishment inspected 99 new homes to see how well they complied with building regulations, one-third failed the standards for airtightness. A common shortcoming was holes round pipes where they went through walls. Property owners

> that want to ensure that insulation has been properly fitted can use thermal-imaging cameras to spot areas where heat is being lost.[295]

And what else should we do if we want to avoid the worst case climate change scenario in 2030 with which I opened this section? Lord Robert May, Fellow of Merton College, Oxford, and formerly Chief Scientific Adviser to the Government (and, perhaps, Britain's most distinguished scientist), spelled it out very well in The Times Literary Supplement. After noting that there has been a collapse in the market for 4X4 sports utility vehicles in the UK he provided the following advice, most of which I agree with:

> But what actions should we be taking? One thing is clear: the magnitude of the problem is such that there is no single answer. Our possible actions can be usefully divided into four categories.
>
> First, we can adapt to change: stop building on flood plains; start thinking more deliberately about coastal defences and flood protection, recognizing that some areas should, in effect, be given up.
>
> Second, we can reduce wasteful consumption, in the home, marketplace and workplace: we can now design houses which consume roughly half current energy levels without significantly reducing living standards.
>
> Third, and necessary in the medium term while we continue to burn fossil fuels, we could capture as much as possible of the carbon dioxide emitted at source, and sequester it (burying it on land or under the seabed).
>
> Fourth, we could move more rapidly towards renewable sources of energy, which do not put greenhouse gases into the atmosphere: these include geothermal, wind, wave and water energy; solar energy (from physics-based or biology-based devices); fission (currently generating 7 per cent of all the world's energy, and – despite its problems – surely playing a necessary role in the medium term); fusion (a realistic long-term possibility); biomass (assuming that the carbon dioxide you put into the atmosphere was carbon dioxide you took out when you grew the fuel). Some of these renewables are already being used, others are more futuristic.

> Ultimately, we need a shift in cultural norms, in the mores that shape everyday behaviour. In this sense, the current collapse of sales of SUVs in the UK is perhaps encouraging.[296]

Even though the United Kingdom emits only 2 per cent of the world's carbon dioxide, British politicians are leading the way in legislating to prevent climate change from becoming too severe. Following a two year campaign called 'The Big Ask'[297] by Friends of the Earth the British government announced a new Climate Change Bill in November 2006 and in March 2007 published a first draft of what the legislation will cover. The announcement reads:

> The Government's blueprint for tackling climate change is published today (13 March 2007).
>
> The draft Climate Change Bill, the first of its kind in any country, and accompanying strategy, set out a framework for moving the UK to a low-carbon economy. It demonstrates the UK's leadership as progress continues towards establishing a post-Kyoto global emissions agreement.[298]

The Tyndall Centre produced a thoughtful response not long after the draft bill was published. The analysts working at the Centre criticized the bill for not covering aviation or shipping and warned that instead of reducing the likelihood of us suffering the worst effects of climate change, the mistaken logic behind the proposals in the bill would actually cause global warming to increase considerably more than the target set by the IPCC.

Two months after the bill's publication, Mike Childs, Head of Campaigns for Friends of the Earth (and a consulting referee on this section of this report) referred to the criticism made of the bill by three parliamentary committees when he said:

> 'The Climate Change Bill must be strengthened. This is the clear conclusion from this joint report by members of the House of Commons and House of Lords. Gordon Brown now has a golden opportunity to demonstrate his green credentials. The Government must listen; it must include international aviation in the emissions reductions targets and it must set a higher target to cut emissions based on the latest scientific evidence.'[299]

The bill was finally enacted in November 2008 and its aim was summaries in a preamble:

> An Act to set a target for the year 2050 for the reduction of targeted greenhouse gas emissions; to provide for a system of carbon budgeting; to establish a Committee on Climate Change; to confer powers to establish trading schemes for the purpose of limiting greenhouse gas emissions or encouraging activities that reduce such emissions or remove greenhouse gas from the atmosphere; to make provision about adaptation to climate change; to confer powers to make schemes for providing financial incentives to produce less domestic waste and to recycle more of what is produced; to make provision about the collection of household waste; to confer powers to make provision about charging for single use carrier bags; to amend the provisions of the Energy Act 2004 about renewable transport fuel obligations; to make provision about carbon emissions reduction targets; to make other provision about climate change; and for connected purposes[300].

On May 4, 2007 the IPCC published its fourth report (and for the present, final report – the next IPCC assessment is not due until 2013) on climate change, 'The Mitigation Of Climate Change'. [301] This document spelled out how the global community can tackle climate change.

The Economist commented:

> Some greenhouse-gas emissions, as the IPCC points out, can be cut at no cost at all—through straightforward measures such as improving insulation and binning wasteful incandescent light bulbs. Such measures could both save people and companies money, and save the planet from a chunk of carbon emissions. At present, they don't bother to do much, because electricity bills are not threatening enough; but governments might take a hand. The European Commission, for instance, is planning to ban incandescent light bulbs in two years' time.

> Such measures could make a difference, given that lighting accounts for 17 per cent of global power consumption.
>
> In other areas, low-carbon technologies would be more expensive than conventional ones—but not necessarily exorbitant. In power generation, for instance, the biggest single source of carbon, the cost of wind and solar power has fallen sharply over the past couple of decades to the point where, in favourable locations, wind power can compete, in price terms, with more conventional forms of energy. Better still, the cost is likely to fall further. Wind turbines are going to go on getting bigger, and thin-film technology is likely to bring down the price of producing solar panels.[302]

Recycling And The Environment

Packaging goods, chemicals and plastics bring many benefits to the world – e.g., increased carbon efficiency for cars and planes, energy conservation through the use of insulation materials and food preservation through the use of anti-contaminant packaging which can double or even triple the amount of time food stays fresh (which is going to prove very important in the struggle to feed another three billion people). However, the consumer image of packaging products is harmed by thoughtless and careless disposal.

The world is littered with carelessly dumped plastic bags, bottles and packaging. This is a behavourial problem and the responsibility might seem to lie with the careless consumer, but governments have acted in some countries. In 2002 Ireland imposed a 15 cents tax on every plastic bag sold, but as the Guardian reported in 2009, the results were not quite as expected:

> While it was true that the tax led to a dramatic drop in the number of bags being handed out in shops, it also triggered a 400% increase in the number of bin liners and black refuse bags being purchased. The tax also encouraged an increased reliance on paper bags which, according to a number of life-cycle analysis

> studies that have compared the environmental performance of various types of bags, require more energy to manufacture and release more greenhouse gases when degrading following their disposal. And while it is commonly accepted that plastic bags are a genuine blot on the landscape (and seascape), they only represent a tiny fraction of the waste stream by weight or by volume. For example, in the US they account for less than half a percent of domestic refuse[303].

And in February 2011 The Independent newspaper ran the follow story under the headline "Plastic fantastic! Carrier bags 'not eco-villains after all'**":**

> Unpublished Government research suggests the plastic carrier may not be an eco villain after all – but, whisper it, an unsung hero. Hated by environmentalists and shunned by shoppers, the disposable plastic bag is piling up in a shame-filled corner of retail history. But a draft report by the Environment Agency, obtained by the *Independent on Sunday*, has found that ordinary high density polythene (HDPE) bags used by shops are actually greener than supposedly low impact choices.
>
> HDPE bags are, for each use, almost 200 times less damaging to the climate than cotton hold-alls favoured by environmentalists, and have less than one third of the Co2 emissions than paper bags which are given out by retailers such as Primark.
>
> The findings suggest that, in order to balance out the tiny impact of each lightweight plastic bag, consumers would have to use the same cotton bag every working day for a year, or use paper bags at least thrice rather than sticking them in the bin or recycling[304].

But even if the reputation of plastic bags has been somewhat redeemed, packaging material going into landfill is a major concern for some environmentalists. Most plastics take a very long time to degrade in such conditions (typically hundreds of years) and even plastics which some producers class as 'biodegradeable' (or 'oxo-degradable') may not break down when denied the effects of sunlight and/or water.

Another major problem caused by the careless disposal of plastics is seen in the pollution of the world's oceans and beaches. Past carelessness (and, in some cases, criminal neglect) has led to microscopic shards of plastics becoming widespread in the marine environment. In 2004 researchers from the British universities of Plymouth and Southampton reported:

> A team of experts has carried out research which proves – for the first time – that oceans and shores are now contaminated with microscopic plastics and fibres.
>
> Eight scientists from the Universities of Plymouth and Southampton and the Plymouth-based Sir Alister Hardy Foundation for Ocean Science has today published a paper detailing their research in the prestigious international journal Science.
>
> The results of the project, which was funded by the Leverhulme Trust, show that oceans and shorelines are now contaminated with microscopic plastic fragments. In addition, large items of plastic debris are known to be accumulating in the oceans and on beaches, harming marine life including turtles, fish, seabirds and mammals.[305]

Germany, the Scandinavian countries, Austria and Belgium have long been leading the way on recycling as a whole and energy recovery in particular. A combination of strict legislation and public education has pushed recycling rates in these countries to up to a peak of 70 per cent. On the other hand, citizens of countries such as Greece and the United Kingdom have been behaving as irresponsible profligate consumers, historically recycling less than 10 per cent of their potentially recyclable waste. This is changing rapidly, however.

In 2011 The Worldwatch Institute reported:

> Recycling rates across the European Union vary considerably. Western European nations, lead by the Netherlands and Denmark, send less than 10 percent of their waste to landfills, whereas many eastern European and island nations send more than 90 percent. Rates vary within countries as well. Italy, for instance, sends half its waste to landfills

> overall, but it is currently facing a European Commission lawsuit for its failure to dispose of uncollected trash in the city of Naples[306].

Meanwhile other forms of packaging (perfume, cosmetics, etc.) have in a few cases become a perverted end in itself and requires regulation. Certainly some forms of packaging are simply plain daft (shrink-wrapped coconuts) but such examples form only a small minority of the market.

It seems clear that given improvements in recycling options which will occur over the next twenty years we must all work towards creating a 'zero waste' society. As is often the case with really good ideas, the concept of zero waste is not new. It was first developed in 1971 by the American biologist and former US Presidential candidate Barry Commoner[307] in his far-seeing book 'The Closing Circle.' He writes:

> Suddenly we have discovered what we should have known long before: that the ecosphere sustains people and everything that they do; that anything that fails to fit into the ecosphere is a threat to its finely balanced cycles; that wastes are not only unpleasant, not only toxic, but, more meaningfully, evidence that the ecosphere is being driven towards collapse.[308]

Four decades later cities and corporations are trying to make the aptly named Commoner's vision come true. As CNN reported in 2007:

> Wal-Mart and the city of San Francisco do not have much in common, but there is this – both are working to achieve zero waste.
>
> They aren't alone. The Australian territory of Canberra, a third of local governments in New Zealand, the cities of Oakland and Berkeley, a bunch of small towns in California, and Carrboro, N.C., ('Paris of the Piedmont') all have embraced a goal of zero waste.
>
> But what is zero waste? It's just what it sounds like – the idea that we can design, produce, consume and recycle products without throwing anything away. It's the idea that industry should mimic nature, so that,

> as the writer Joel Makower put it, ‘one species' detritus is another's pantry.’[309]

And in March 2011 more than 30 people coming from 13 European countries – Belgium, Bulgaria, Croatia, Estonia, France, Germany, Greece, Italy, UK, Czech Republic, Rumania, Spain and Hungary –got together in the first meeting to define the Zero Waste strategy for Europe. The event was organised by GAIA and EEB[310].

By the year 2030 we will all have learnt to conserve, recycle and reuse. We don’t have a choice. With over eight billion of us on the planet our resources, natural or human-made, will be stretched almost to the limit. Of course we will learn to make more of everything – that is the wondrous ability of humanity and its technologies – but the irresponsible profligacy that is today’s defining characteristic of the developed world will have disappeared for ever. In its place will be a new form of consumerism; we will still have our goods and services but we will all know how they arrived and where they go once we have finished with them. Not to be responsible for the resources we consume will, by 2030, have become a moral crime. It may even have become a legal crime.

Part Three

The Future of Energy

Consulting Referee
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Little in our world is as politically charged as energy generation and energy supply. Perhaps only national defence is regarded by governments as having more strategic importance. Just as individual humans must consume energy each day to survive, so must our modern high-tech societies. Politicians know that if there is a sustained failure in energy supply, or a long-term shortage of gasoline, citizens will take to the streets.

In 'The Hydrogen Economy' Jeremy Rifkin describes the social and political role of energy in stark terms:

> Societies collapse when the energy flow is suddenly impeded. Energy is no longer available in sufficient volume to sustain the increased populations, defend the state against intruders, and maintain the internal infrastructure. Collapse is characterised by a reduction in food surpluses; a winnowing of government inventories; a reduction of energy consumed per capita; disrepair of critical infrastructures like irrigation systems, road, and aqueducts; increasing popular defiance

> towards the state; growing lawlessness; a breakdown in central authority; a depopulation of urban areas; and increasing invasions and pillaging by marauding groups or armies.[311]

Nations go to war to secure their long-term supplies of energy and alarm bells have started to sound in many countries because projections suggest that the world is going to demand much more energy between now and 2030. And in that time-frame global oil reserves will start to run out.

Estimates for future energy consumption vary widely, but at a minimum it is suggested that world energy consumption will increase by 50 per cent[312] by 2030 and the maximum projected increase is put at 100 per cent.[313] These nice round figures indicate just how 'approximate' some of the future projections necessarily are but they also illustrate a grave problem; in an era in which we have to cut our carbon emissions by at least 40 per cent by 2030 (and at the very least 60 per cent by 2050), how are we going to find sufficient energy of the right kind to meet our enlarged needs?

Ray Kurzweil, ever the optimist, sees a radical solution to the looming energy crisis coming from technology:

> By 2030 the price-performance of computation and communication will increase by a factor of ten to one hundred million compared to today. Other technologies will also undergo enormous increases in capacity and efficiency. Energy requirements will grow far more slowly that the capacity of technologies, however, because of greatly increased efficiencies in the use of energy. A primary implication of the nanotechnology revolution is that physical technologies, such as manufacturing and energy, will become governed by the law of accelerating returns. All technologies will essentially become information technologies, including energy.
>
> Worldwide energy requirements have been estimated to double by 2030, far less than anticipated economic growth, let alone the expected growth in the capability of technology. The bulk of the additional energy needed is likely to come from new nanoscale solar, wind and

> geothermal technologies. It's important to recognize that most energy sources today represent solar power in one form or another.[314]

Could Kurzweil be right? I think it possible that new technology development *may* significantly reduce energy consumption and provide new sources and forms of energy, but this cannot be relied upon.

For the present, therefore, we are faced with a world divided by competing claims for fossil fuel energy, a global economy that is very vulnerable to shocks from the energy market and a world in which nation states use energy supply (or denial of supply) as a political, power-broking weapon.

In a 2009 paper called 'Russia's Energy Weapon and European Security', Professor Stephen Blank of the U.S. Army's Strategic Studies Institute wrote:

> Whether or not individual European governments and the EU claim that Russian energy and their dependence upon it is Moscow's weapon to secure their compliance with Moscow's preferences, Russia clearly believes that its gas and oil serve precisely that purpose. Similarly other analysts have also discerned the links between Russia's energy strategy and its overall security strategy in Europe. Russia has also repeatedly used energy, threats or actual cutoffs to punish states that have conducted policies that it does not like. Russia's 2003 energy strategy and subsequent statements by President Vladimir Putin make it clear that energy is Russia's most important instrument of foreign policy and that energy policy's purpose is to facilitate Russia's return to great power status in Eurasia[315].

Because energy is such a deeply political issue in most countries governments control the generation, importation and supply of energy to industry, business and consumers.

The two notable exceptions to national and semi-national energy monopolies are Britain and, to a lesser extent, the United States – although since the 2007 edition of this book the European Union has made great strides towards laying the foundations of an open energy market across Europe.

After years of foot-dragging legislation aimed at opening the European Union (EU) energy markets was adopted by the European Parliament in Spring 2009 and was implemented in member states in early 2011.

The development of renewable energy - particularly energy from wind, water, solar power and biomass - is another central aim of the European Commission's energy policy.

> Renewable energy has an important role to play in reducing Carbon Dioxide (CO_2) emissions - a major Community objective. Increasing the share of renewable energy in the energy balance enhances sustainability. It also helps to improve the security of energy supply by reducing the Community's growing dependence on imported energy sources.
>
> Renewable energy sources are expected to be economically competitive with conventional energy sources in the medium to long term.[316]

As promised, in early 2011 the EU laid down the timetable for the long overdue opening of the European energy market as reported by the journal Utility Week:

> European Union political leaders last week formally agreed that Europe's energy market must be fully open by 2014. The deadline was one of the highlights of the EU summit, hailed by energy commissioner Gunther Oettinger as "a breakthrough for European energy policy".

> …New technical standards for electric vehicle charging systems should be adopted by 2011 and for smart grids and metering by the end of 2012, the summit decided. The leaders also reiterated backing for national support schemes such as feed-in tariffs for renewable energy and for improved inter-state network connections. State aid, they said, would be acceptable in some circumstances to improve grid links[317].

Consumer education, political thinking and cultural attitudes play a large part in shaping how we consume energy and how much energy we consume. The United States has a population equal to only 5 per cent of the global total but the nation consumes 25 per cent of the world's energy. Europe has a far lower consumption of energy but the standard of living is just as high as in the USA

In 'The Extreme Future' James Canton sums up the American cultural attitude to energy use as follows:

> The American public, unlike the Europeans, has been spoiled by cheap oil, which has created the illusion of plenty while the reality of diminished reserves has escaped public scrutiny. The Europeans accelerated this public awareness by taxing gas, making it routinely two to three times as expensive as gas in the US. More than 85 per cent of new auto buyers in Europe are concerned with fuel efficiency. Fewer than 15 per cent of Americans care about fuel efficiency, because in a world of cheap oil, they don't have to.[318]

It is fair to say that America now finds itself in a truly lousy position regarding the future security of its energy supplies. The country has an extreme dependence on imported oil and a cultural and political dependence on low energy prices. It also has poor security over its future oil supplies which may make the heavily-armed nation even more dangerous to the rest of the world in the decades to come. And the recent change in mood about building new nuclear power stations has only made the U.S. position more desperate.

As The Wall Street Journal reported in September 2011:

> Japan's Fukushima Daiichi disaster is having an unanticipated effect: It is forcing the world to become more reliant than ever on aging nuclear plants, and if utilities have their way, those plants will run decades longer than envisioned.
>
> A batch of new reactors had been planned for the U.S. and other nations, but the backlash against nuclear power triggered by the disaster has dimmed prospects for a "nuclear renaissance." Few nations, however, have expressed any intention of giving up existing plants, often considered essential for meeting power demands.
>
> In the U.S., two-thirds of nation's 104 nuclear reactors have had their original 40-year licenses extended by 20 years, including nine extensions granted since the Japan accident. Regulators are conducting research to see if U.S. reactors could be pushed to 80 years. France's nuclear regulator is plowing ahead with plans to extend the life of some plants to 60 years[319].

However, and seemingly contradictorily, in the UK of over 2000 citizens polled six months after the Fukushima disaster 54 per cent wanted either the number of British nuclear power stations increased or the existing stations to be replaced as they are decommissioned[320].

In the light of the need for urgent action on climate change, a looming shortage of oil and predictions that suggest that the world will consume up to double the amount of energy by 2030, governments around the world are rising to the challenge in various ways and with varying degrees of commitment.

In Germany the use of renewable energies increased from 6.3 percent of the national total used in 2000 to about 16.1 percent in 2009 and the national has even more ambition plans. As The Guardian reported in 2010:

> Germany could derive all of its electricity from renewable energy sources by 2050 and become the world's first major industrial nation to kick the fossil-fuel habit, the country's Federal Environment Agency said today.
>
> The country already gets 16% of its electricity from wind, solar and other renewable sources – three times' higher than the level it had achieved 15 years ago[321].

France, on the other hand, produces 80 per cent of its energy in nuclear power stations although the French government plans to increase the renewable share of the country's total energy consumption from 6.7 percent in 2004 to 20 percent by 2020.

But following the Fukushima disaster, even France exhibited caution over its large nuclear-power stockpile of reactors. As the Wall Street Journal Europe reported two weeks after the Japanese seismic events:

> French Prime Minister François Fillon has requested the country's nuclear-safety agency Autorité de Sureté Nucléaire to conduct an audit of France's 19 nuclear plants and 58 nuclear reactors, according to a letter made public Thursday.
>
> Plants will be audited one by one, with the aim to specifically detect any issue that could be linked to potential floodings, power outages, seismic activity or a drop in reactor cooling, as well as to assess the handling process of potential accidents, Mr. Fillon said in his letter[322].

Italy phased out all nuclear power in 1990 following the Chernobyl disaster. Since that time, Italy has become the world's largest larger importer of power, importing approximately 10% of its electricity from nuclear-dependent France. However, in 2008 attitudes to nuclear power in Italy changed and, until the disaster at the Fukushima nuclear site in 2011 Italy was planning a substantial new programme of nuclear power station construction.

Nuclear Power

Nuclear power generation is a topic that is extremely divisive within environmental groups and within governments. Many environmentalists have strong emotional attachments to anti-nuclear campaigns whilst some individual environmentalists, most notably James Lovelock, who until recently was urging his fellow 'greens' to break with tradition and endorse carbon-lite nuclear power generation for the sake of the planet. Up until March 2011 the Zeitgeist seemed to be favouring nuclear power generation once again and, in 2011 over 60 reactors were currently under construction in 15 countries[323]. Since the earthquake and tsunami in Northern Japan all such idea are on hold – or, at the very least, are being reviewed.

As must have already become apparent in this section, energy generation and supply is wholly politicized and it is very difficult to get at the truth about something as important to nation states as nuclear reactors.

Whilst it is true that nuclear power generation produces electricity without carbon emissions (about 6 per cent of the world's total energy generation), it is not true to say that there is no environmental impact from the process. The biggest problems are the risk of catastrophic accidents and finding safe ways to dispose of nuclear waste. This latter problem remains largely unresolved. Most of today's nuclear waste is simply stored in what is believed to be a safe manner until a satisfactory method of disposal has been developed. And it is also true to say that reserves of uranium on our planet may be limited. Although no serious exploration for new uranium deposits have been undertaken for twenty years (because nuclear power has been so

much out of favour), current estimates suggest that if a new nuclear age were to dawn there were only be enough uranium available for 60-70 years of power production.

In 2007 I was not in favour of building more nuclear power stations to help the world reduce its greenhouse gas emissions and there were three other reasons why, in 2007, I was wary of advocating additional nuclear power generation to help reduce the problems of climate change.

The first was (and it remains the case) that consumers don't know the true cost of the energy generated by nuclear power stations. Just as consumers aren't (at present) told the cost of the damage that fossil fuels do the environment as energy is produced (and that cost is not yet levied on the consumer) so the unit of power generated by a nuclear power station is not priced in a way that reflects the huge cost of mining and refining nuclear fuel, building the nuclear power station, the huge cost of decommissioning the plant after use and the ongoing cost of storing the radioactive waste. All of these costs are borne by 'the general taxpayer' over a long period (during which politicians, governments and civil servants change, thus evading individual and even collective responsibility) and there is no transparency in the process. We therefore have no idea how economic or uneconomic nuclear power is when compared to other forms of power generation.

This objection holds for governments all around the world and the nuclear industry has a vested interest in keeping such information opaque. Professor Dan Kammen of the University of California (Berkley) co-authored a report entitled 'Weighing the financial risks of nuclear power (unknown)':

> ‘For energy security and carbon emission concerns, nuclear power is very much back on the national and international agenda,’ said study co-author Dan Kammen, UC Berkeley professor of energy and resources and of public policy. ‘To evaluate nuclear power's future, it is critical that we understand what the costs and the risks of this technology have been. To this point, it has been very difficult to obtain an accurate set of costs from the US fleet of nuclear power plants.’[324]

The point about the hidden costs of nuclear power generation is well made. In Spring 2011 The Economist reported on the time taken and the costs of cleaning up an old nuclear power station at Hanford, Washington State:

> At the Hanford site, which sprawls across a sagebrush plain in the south-east of the state, none of the 53m gallons (200m litres) of highly toxic waste stored in 177 ageing and leaky underground tanks has been mopped up, even though the last reactor was shut down in 1987. That must wait until 2019, when a unique waste-treatment plant—described as the largest and most expensive nuclear clean-up project ever undertaken—will begin transforming radioactive leftovers that could poison the nearby Columbia river into still-radioactive glass logs more suitable for long-term storage. If all goes well, gunk-to-glass processing (“vitrification”) will continue until at least 2047 and cost about $74 billion, more than the annual budget of America’s Department of Education[325].

My second additional reason for believing that we should pursue the development of renewable or sustainable energy sources rather than nuclear power was the problem of nuclear proliferation. If the present nuclear powers continue to increase their nuclear power generation resources there are no moral grounds to suggest that other, less developed countries, should not do the same thing. And as the number of nuclear reactors in the world proliferates, so does the opportunity for the building of nuclear weapons.

My third additional reason for believing that nuclear energy production should be scaled down rather than ramped up was that the more nuclear power stations there are, the more targets for international and domestic

terrorists exist. We know that we currently live in an age of extreme danger from international terrorist ideologies and the cost and difficulty of protecting nuclear installations from terrorist attacks must be enormous – as would be the risk to the public if a major attack on a nuclear plant were ever to succeed. It is also pertinent to add that nuclear power stations in some regions of the world are also vulnerable to earthquakes and tsunamis.

But the last few paragraphs above are reprinted from the 2077 edition of 'The World In 2030'. As I said in the new foreword, until the severe problems at the Daiichi power station in Fukushima, Japan I had been coming to the conclusion that the effects of global warming are likely to be so severe that we might just have to resort to building new nuclear power generation facilities after all. But, even though such a reaction is probably illogical, I now think very few democratic governments are likely to press ahead with large new nuclear power construction programmes.

As the New York Times reported not long after the crisis at the Japanese nuclear power plant:

> Until this weekend, President Obama, mainstream environmental groups and large numbers of Republicans and Democrats in Congress agreed that nuclear power offered a steady energy source and part of the solution to climate change, even as they disagreed on virtually every other aspect of energy policy. Mr. Obama is seeking tens of billions of dollars in government insurance for new nuclear construction, and the nuclear industry in the United States, all but paralyzed for decades after the Three Mile Island accident in 1979, was poised for a comeback.
>
> Now, that is all in question as the world watches the unfolding crisis in Japan's nuclear reactors and the widespread terror it has spawned[326].

And in April 2011 The Independent report on research that claimed one in ten nuclear power generating stations around the world are at risk of earthquake:

> Scores of nuclear power plants worldwide are at risk from tsunamis or earthquakes similar to the natural disasters that crippled Japan's Fukushima reactors, according to new research. Many at-risk plants are in countries less able to cope with a disaster than Japan, experts have warned.
>
> Seventy-six operating power stations in Japan, Taiwan, China, South Korea, India, Pakistan and the US are located in areas close to coastlines deemed vulnerable to tsunamis.
>
> Of 442 nuclear power stations globally, more than one in 10are situated in places deemed to be at high or extreme risk of earthquakes – in Japan, the US, Taiwan, Armenia and Slovenia – according to a new study by the analysts Maplecroft[327].

The Future For Fossil Fuels

Except for nuclear-generated power all forms of energy in the world come directly, or indirectly, from the sun. The most concentrated form of energy available is that which was trapped millions of years ago as small sunlight-consuming cellular animals and plants were crushed and buried beneath the surface of the Earth and its oceans (producing oil, coal and gas, in the main). The compressed remains of these energy rich organisms are called ‘fossil fuels’ and, because they have been a) relatively easy to mine and, b) we haven’t realized until recently the effects of releasing the carbon they contain into the atmosphere as we consume them, we have burnt them indiscriminately.

Today, fossil fuels still provide about 80 per cent of the world's energy[328] and most commentators believe that by the year 2030 the world will still be obtaining the majority of its energy from such fuels.

In ascending order of 'dirtyness' (in carbon terms) these fossil fuels are, natural gas, oil and coal. Oil and gas reserves are spread very unevenly in the world which, for the moment, gives those nations with the largest reserves great economic and political power. Coal on the other hand is widely distributed around the planet and is the much used and easy antidote to the power wielded by the oil and gas nations, currently supplying (by one estimate) 24 per cent[329] of the world's energy needs. For political reasons coal is a favourite of many governments, even if it is often the most polluting form of fuel.

Until recently the United States was planning to build many more coal-fired power stations in an attempt to reduce its dependence on energy imports. But environmental pressures and the global credit crisis have forced the scaling back of plans announced during the administration of George W. Bush. As the New York Times reported from the mid-West in 2010:

> ON the coasts, states are limiting carbon dioxide output, banning new coal-fired power plants and building wind turbines to fend off global warming. But here in the heartland, thousands of workers are building a $4 billion new coal plant with a 700-foot chimney, 70 feet higher than the Gateway Arch in St. Louis.
>
> Around the country, construction of coal plants has been slowed, partly by opposition but also by the recession, which has stunted electric demand and forced cancellation or deferral of all kinds of utility projects. But numerous coal plants under construction today are likely to be pumping out carbon dioxide profusely until at least 2050, when,

> as President Obama would have it, American carbon output will be 80 percent lower[330].

Coal is also one of the main energy sources for the developing world. In 2010 about 80 per cent[331] of India's electricity (up from 70 per cent in 2007) was generated from coal and the figure in China was also 80 per cent. [332]

And, as the first edition of this book was being written, environmentalists were dismayed to learn that China has unexpectedly shot to the top of the list of the world's largest emitters of greenhouse gases, years before such a 'promotion' was anticipated. Under the headline 'China overtakes US as world's biggest CO_2 emitter', the Guardian commented in June 2007:

> According to the Netherlands Environmental Assessment Agency, soaring demand for coal to generate electricity and a surge in cement production have helped to push China's recorded emissions for 2006 beyond those from the US already. It says China produced 6,200m tonnes of CO_2 last year, compared with 5,800m tonnes from the US. Britain produced about 600m tonnes.[333]

The World Coal Institute[334] asserts that coal supplies 40 per cent of the world's electricity, but this figure is at odds with the US government's claim that coal's current share globally is 24 per cent and this highlights just how difficult it is to find reliable information about something as politically important as energy. But whatever the true figure, it is clear that coal will continue to play a major role in generating electricity.

But does coal-fueled power generation have to be the filthy source of carbon emissions it is today? In April 2007 The Massachusetts Institute of Technology produced a report called The Future Of Coal. The report's authors came to the following conclusion:

> There are many opportunities for enhancing the performance of coal plants in a carbon-constrained world – higher efficiency generation, perhaps through new materials; novel approaches to gasification, CO_2 capture, and oxygen separation; and advanced system concepts, perhaps guided by a new generation of simulation tools. An aggressive R&D effort in the near term will yield significant dividends down the road, and should be undertaken immediately to help meet this urgent scientific challenge.[335]

Capturing and 'sequestering' the carbon (storing the CO_2 in an environmentally benign way) will be big business by 2030. The German industrial giant Siemens intends to play a large role in applying this technology to coal-fired power generation. In Spring 2007 it issued a press release headed Coal Gets Cleaner:

> If all coal-fired power plants were upgraded today with the latest technology, then the amount of carbon dioxide emissions would be reduced by about two billion tons annually.
>
> Siemens and EON are working together on a new power plant project in Irsching, Bavaria, that will be set the new standards for performance capacity, economy and environmental compatibility. With a targeted efficiency of 60 per cent in a combined cycle operation (gas and steam), Siemens seeks to set the world record for combined cycle power plants.
>
> Siemens is also working on innovative power plant designs for the environmentally compatible use of coal. One example is the so-called IGCC technology, or integrated gasification combined cycle.
>
> An IGCC power plant is a combined cycle generating facility with an upstream coal gasification plant that produces synthetic gas. The IGCC plants produce between 60 and 80 per cent less sulfur dioxide and nitrogen oxide than the most advanced conventional coal-fired power plants.[336]

And getting rid of CO_2 by pumping carbon into rocks also has great potential for producing clean energy. According to the New Scientist:

> Pumping carbon dioxide through hot rocks could simultaneously generate power and mop up the greenhouse gases produced by fossil fuel power stations, according to a new study.

> Harnessing geothermal power involves extracting heat from beneath the surface of the Earth. Normally, this means pumping water down through hot rocks and extracting it again. But the new analysis suggests carbon dioxide could extract heat from rocks more efficiently than water.[337]

Oil is the second most polluting form of fossil fuel but, as it is the world's most widely used source of energy (40 per cent[338] – providing 96 per cent of energy used for transportation[339]), it is the biggest overall contributor to carbon emissions. But of all three fossil fuels, oil looks as if it will be the first one to come close to running out. Oil will not run out completely for a very long time, but as it becomes more scarce prices will rise to the point that it cannot be used as fuel for personal and mass transportation. Oil will then be reserved for high value processes and products such as chemicals production and plastics manufacturing.

Over the decades much has been written about the future of oil supplies and in 2007 The Financial Times gloomily reported:

> The world is facing an oil supply 'crunch' within five years that will force up prices to record levels and increase the west's dependence on oil cartel Opec, the industrialised countries' energy watchdog has warned.
>
> In its starkest warning yet on the world's fuel outlook, the International Energy Agency said 'oil looks extremely tight in five years time' and there are 'prospects of even tighter natural gas markets at the turn of the decade'.[340]

However, as soon as one authority suggests reserves will soon be running out it seems that new reserves are discovered or new methods of more efficient extraction are found. For example, The New York Times reported bullishly in March 2007:

> Will we seek a peak production year (2010?) and will supplies after that become erratic and uncertain? No.
>
> More oil available than thought – new steam pressure method raises extraction rates from existing field. Some of the gas pumped back is CO_2.
>
> Chevron[341] engineers here started injecting high-pressured steam to pump out more oil. The field, whose production had slumped to 10,000 barrels a day in the 1960s, now has a daily output of 85,000 barrels.

However, the beginning of the end of the global oil supply (peak production year) will almost certainly have occurred by the time we reach 2030. In the meantime, world demand for oil continues to soar, especially in the developing countries.

As the Institute For The Analysis For Global Security reported in 2011:

> From now to 2020, world oil consumption will rise by about 60%. Transportation will be the fastest growing oil-consuming sector. By 2025, the number of cars will increase to well over 1.25 billion from approximately 700 million today. Global consumption of gasoline could double.
>
> The two countries with the highest rate of growth in oil use are China and India, whose combined populations account for a third of humanity. In the next two decades, China's oil consumption is expected to grow at a rate of 7.5% per year and India's 5.5%. (Compare to a 1% growth for the industrialized countries). It will be strategically imperative for these countries to secure their access to oil[342].

The problem with oil is that most of it is used for transportation and no practical means of extracting (or sequestering) CO_2 at the point of vehicular emission exists, nor is thought to be practical in the future. The future for

the oil industry may remain bright, but way before 2030 governments, businesses and consumers must have sharply reduced their reliance on this energy source.

Natural gas is the cleanest of all fossil fuels and its availability and popularity over the last few decades has already had a mitigating impact on climate change. The Living Carbon Budget report prepared for Friends of the Earth by the Tyndall Centre illustrated how natural gas has helped the UK constrain its carbon emission from power generation:

> One key progression however, is the change in carbon intensity of the UK's electricity grid. Over the long-term, the grid has gradually become less carbon intensive, with a step change during the 1980s and 1990s with the move from coal-fired power to gas.
>
> Therefore, despite the near doubling of electricity demand over the long-term, the carbon emissions associated with electricity generation have shown a very moderate increase of around 8 per cent (4MtC) over the same period.[343]

Natural gas trails coal as the most popular fuel for the future (presumably for political reasons) but it is predicted to increase slightly its current share of the global energy mix.

However, in early 2007 The Gulf Times reported that natural gas is currently the fastest growing component of the world energy mix and its share will rise to 25 per cent by 2025, and the US government's Energy Information Administration predicted:

> Natural gas trails coal as the fastest growing primary energy source in 2006. The natural gas share of total world energy consumption increases from 24 per cent in 2003 to 26 per cent in 2030.[344]

And in 2010 the U.S. Energy Information Administration reported:

> Natural gas remains a key energy source for industrial uses and for electricity generation throughout the projection. The industrial sector accounted for approximately 40 percent of total world natural gas use in 2007, and it maintains that share through 2035. Because natural gas produces less carbon dioxide when it is burned than does either coal or petroleum, governments implementing national or regional policies to reduce greenhouse gas emissions may encourage its use to displace other fossil fuels. In the electric power sector, for example, natural gas is often an attractive choice for new generating plants because of its relative fuel efficiency, low emissions, quick construction timelines, and low capital costs. Electricity generation … becomes an increasingly important part of the world's natural gas consumption, accounting for 36 percent of the world total in 2035, up from 33 percent in 2007[345].

Energy Efficiency and Conservation

With such a large increase in energy consumption predicted between now and 2030 (by all commentators), with the menacing problem of climate disease and with the fact that some fossil fuels are running out we have no option but to conserve energy aggressively and to use fuel in the most efficient manner possible. Because we have previously been living in a period of 'cheap energy' and social carelessness there is huge room for improvement in our current patterns of usage.

Most energy wastage occurs in the heating and cooling of buildings and insulation technologies have a major role to play in protecting spaces against thermal transfer (either heat loss or cooling loss) and in providing components for construction which are very much more thermally efficient than traditional materials.

And the quest for energy efficiency and environmental friendliness reportedly played a large part in Britain's securing of the 2012 Olympic Games for London. As the BBC reported:

> The environmental plan for the 2012 Summer Olympic Games focuses on four areas: low-carbon emissions, waste, biodiversity, and promoting environmental awareness.
>
> Below is a summary of how the Games' organisers intend to turn the aspiration to stage a 'One Planet Olympics' into a reality.
>
> Venues and infrastructure: Minimise the Games' carbon 'footprint' during the design, construction and operational stages. One way the team aims to achieve this is by maximising the use of renewable energy and providing the most efficient energy supply in the new Olympic park.
>
> Transport: The most carbon-efficient fleet of vehicles will be used to ferry officials and competitors to and from venues. There will also be campaigns to encourage people to use public transport, cycle and walk to events.
>
> Offsetting emissions: Some aspects of staging the Games will involve unavoidable emissions, such as people flying into the UK from all over the world. Organisers plan to offset these emissions by supporting and developing clean energy projects in developing nations.[346]

By 2030 preparations will be well ahead for the Olympic games of 2032 which will probably be held in Los Angeles (2032 will be the centenary of when the games last visited the city). How much more carbon efficient will those games be than the games due to be held in London this year (in 2012)? Will near-to-zero energy loss have been achieved or will the necessary evil of aviation (flying in all the competitors, spectators and officials) ruin such efforts? Or will the jets of 2032 be running mainly on biofuels?

Other areas where energy efficiency can be vastly improved include computing and IT, transport and, once again, power generation and distribution. All areas have huge potential for energy saving simply because after a century or more of cheap energy, efficiency has not been the foremost design parameter when products or projects have been in development.

In computing I.B.M. has made it clear in 2007 that significant savings can be made:

> I.B.M. is beginning a $1-billion-a-year investment program intended to double the energy efficiency of its computer data centers and those of its corporate customers.
>
> Many technology companies are trying to curb the runaway energy consumption of data centers, the modern engine rooms that power the Internet and corporate computing.
>
> By 2010, I.B.M. plans to double the computing capacity of its hundreds of data centers worldwide without increasing power consumption, by using an array of hardware, software and services. These include a new cooling system that stores energy and chills the data center only as needed; software to increase the use of computers and automatically switch them to standby mode when not needed; and 3-D modeling and thermal engineering techniques to optimize the air flow through data centers.[347]

And I.B.M followed through on its promise as ZD Net reported in 2009:

> Making data centers more energy efficient has been a growing priority for technology managers for the past few years, as companies seek to trim spending on electricity and reduce their environmental footprint. The Environmental Protection Agency in 2007 estimated that data centers alone use about 1.5 percent of all electricity in the U.S. and are on a pace to double consumption in the coming years. In IBM's case, it deals with high volumes--its wikis are used by 365,000 people--and a growing number of applications.
>
> IBM's tech staff did what many others in their position have done: they consolidated their computing workload with virtualization and upgraded to new, more energy-efficient hardware[348].

There is also scope for enormous improvement in goods and passenger vehicle economy. The success of the hybrid electric-petrol Toyota Prius car in both the USA and parts of Europe indicates where vehicle design is heading. In standard form the Prius returns about 50 miles to the US gallon

(3.92 litres per 100 kilometres), but it can easily be tweaked to double its fuel efficiency:

And there is even talk at the Sustainability Institute of designing cars of the future that will be able to do 1,000 miles to the US gallon (0.23 litres per 100 kilometres):

> In today's most efficient cars, only 15-20 per cent of the energy in the gas gets to the wheels. Only about 2 per cent actually moves the driver; the rest hauls the ton of metal around the driver. Because of that ton of metal, engines have to be enormous. The key to the Supercar is to make it 1) much lighter and 2) much more aerodynamic, which would then allow it to have 3) a much smaller, more efficient engine.
>
> The lightness comes from getting rid of the steel. The Supercar will be made of composite materials - carbon-fiber, fiberglas, and plastic specially designed to absorb far more crash energy per pound than metal. You've watched these materials at work if you've ever seen an Indy-500 driver hit a wall at 200 mph and walk away. Race cars are made of carbon-fiber. This material can be reclaimed and recycled, by the way, and it doesn't rust.[349]

Power Generation And Distribution

One of the most serious areas of energy wastage in the world is power generation and conversion. Most coal-fired power stations are only about 30 per cent efficient (70 per cent of the energy in the fuel burned is wasted) and much power is lost during long distance transmission over wires (how much depends on the distance and the wires).

Huge improvement in the efficiency of power stations[350] are possible and are now being vigorously pursued. One idea is to extract energy from the heated waste steam. Researchers at the University of California (Berkley)

have discovered how to produce electricity directly from heat using nano molecules:

> Nano molecules produce electricity when heated. Now, new research shows that certain organic molecules produce voltage when exposed to heat. Ultimately, they could be much cheaper and thus more practical to implement.
>
> If all goes well, though, so-called thermoelectric devices based on the molecules could prove to be an important source of power – and a way to reduce greenhouse-gas emissions by making far more efficient use of fossil fuel. 'Ninety per cent of the world's electricity is generated by thermal-mechanical means,' says Arun Majumdar, professor of mechanical engineering at UC Berkeley and another researcher on the project. 'And a lot of the heat is wasted. One and a half times the power that is generated is actually wasted.'[351]

And there may also be the potential for saving the energy lost during power transmission. Referring to the pioneering work done by Professor R.E. Smalley[352] of Rice University, Ray Kurzweil writes:

> Transmission of energy will also be made far more efficient. A great deal of energy today is lost in transmission due to the heat created in power lines and inefficiencies in the transportation of fuel, which also represent a primary environmental assault.
>
> Smalley, despite his critique of molecular nanomanufacturing, has nevertheless been a strong advocate of new nanotechnology-based paradigms for creating and transmitting energy. He describes new power transmission lines based on carbon nanotubes woven into long wires that will be far stronger, lighter, and most important, much more energy efficient than conventional copper ones. He also envisions using superconducting wires to replace aluminium and copper wires in electric motors to provide greater efficiency.[353]

And George Monbiot identifies the possible benefits of switching types of current in future power transmission lines from alternating current (AC) to new types of plastic-based direct current (DC) cable.[354] This, he claims, has

the potential to make new forms of renewable energy more economic. In 'Heat' he writes:

> Most importantly, though the initial electricity loss on a DC line is higher, it does not increase with distance. On AC systems, by contrast, the longer the line, the more you lose. There is no inherent limit on the length of a DC cable.
>
> High voltage DC, which can be run along the sea bed, opens up any patch of sea shallower than 50 metres to wind turbines and pretty well all the continental shelf to wave power devices, which (because they float) can be anchored at greater depths. Since wind speeds rise by around one metre per second with every 100 kilometres from the shore, this means that the cost of renewable power could actually fall with distance from the coast…You can install wind turbines which rotate faster (and are therefore both noisier and more efficient) without upsetting anyone.[355]

And, a couple of years after Monbiot's important book was published, The Economist newspaper explored an idea put forward by the ISET Institute[356] at the University of Kassel, in Germany, to create a European-wide DC power grid to allow a free exchange of electricity across Europe. In an article entitled 'Where the Wind Blows' the Economist's correspondent pointed out that although wind turbine generation is an erratic source of power, if a distribution grid were sufficiently large, power could be transferred across Europe from areas where the wind is blowing to areas that are becalmed. The article continued:

> A group of Norwegian companies have already started building high-voltage DC lines between Scandinavia, the Netherlands and Germany, though these are intended as much to sell the country's power as to accumulate other people's. And Airtricity—an Irish wind-power company—plans even more of them. It proposes what it calls a Supergrid. This would link offshore wind farms in the Atlantic ocean and the Irish, North and Baltic seas with customers throughout northern Europe.

> Airtricity reckons that the first stage of this project, a 2,000 turbine-strong farm in the North Sea, would cost about €2 billion ($2.7 billion). That farm would generate 10 gigawatts. An equivalent amount of coal-fired capacity would cost around $2.3 billion so, adding in the environmental benefits, the project seems worth examining. Such offshore farms certainly work. Airtricity already operates one in the Atlantic, and though it currently has a capacity of only 25 megawatts, increasing that merely means adding more turbines. [357]

Which leads us fairly neatly into a discussion about the future of renewable and sustainable energy sources.

Renewable and Sustainable Energy Sources

All the forecasts about the mix of energy we will be using in 2030 that I quoted earlier in this section are wrong. They will be proved wrong because it is impossible to forecast how energy generation and transmission technologies will develop over the next two decades. The one thing that all of the worthy bodies making prognostications about future energy sources and use patterns miss (or ignore) is that joker in the pack, accelerating, exponential technology development.

I think it likely, almost certain, that energy from renewable and sustainable sources will be well on the way to providing the world with the majority of its ever expanding energy needs by 2030; after all, the energy is all around us in the wind, the waves, the rocks and the sun. Enough energy falls on the Earth's surface from the sun in a single hour to meet the world's current energy needs for a year.[358]

Investment has recently been pouring into 'clean tech' energy projects. As Reuters reported in 2011:

> Brazil, China and India are expected to fuel global investments in clean energy in 2011 that are expected to reach $240 billion, the head of a United Nation's green economy initiative said on Wednesday.
>
> The U.N.'s environmental unit (UNEP) said investment in renewable energy hit $180-$200 billion in 2010 up from $162 billion in 2009, driven by the three countries.
>
> The increased investments are because sustainable energy is gaining momentum as governments seek cheaper sources -- such as solar, wind and ethanol -- to cushion against rising oil prices.[359]

Before looking at the type of technologies which might be providing our clean power by 2030 it is worth defining the difference between 'renewable' and 'sustainable' energy sources, even though many commentators seem to use the terms interchangeably.

'Renewable'[360] sources are those natural sources that surround us and which are automatically renewed. These include the sun's radiation, wind power, wave power, tidal movements, hydroelectric power and geothermal power (heat trapped in rocks). Usually very little carbon is emitted in the generation of power from renewable sources.

'Sustainable'[361] resources are crops and biomass that can be used as a source of energy and which can be grown in a way that is environmentally responsible. The cultivation of sustainable fuel sources usually produces some carbon emissions and these last two points are very important when considering the advisability of the current energy policy of the United States, the world's worst polluter.

In an attempt to appear 'green' (and to appease growing public awareness of the dangers of climate change in the United States) the George W. Bush White House provided subsidies to boost the production of bioethanol,[362] a

biofuel[363] made from corn and, in warmer regions, sugarcane (biofuel is a form of alcohol).

The reason that the existing oil industry smiled on this 'biofuel' initiative is that although the feedstock changes, the methods of refining and distributing propellant energy remain the same. The 'Big Oil' infrastructure remains in place and it is almost 'business as usual'.

But there are many serious problems with Bush Jnr.'s policy of boosting ethanol production to fuel motor transport . Environmentalists are falling over themselves to point out just how wrongheaded the policy was on this topic. Even non-aligned and much respected commentators pointed out the mistakes, as The Economist commented in 2007:

> Corn-based ethanol is neither cheap nor especially green: it requires a lot of energy to produce. Production has been boosted by economically-questionable help from state and federal governments, including subsidies, the promotion of mixing petrol with renewable fuels and a high tariff that keeps out foreign ethanol.[364]

The same journal also reported that by using high-quality agricultural land to produce feedstock for ethanol, America is, in fact, choosing to feed its cars rather than its people.

> America's use of corn (maize) to make ethanol biofuel, which can then be blended with petrol to reduce the country's dependence on foreign oil, has already driven up the price of corn. As more land is used to grow corn rather than other food crops, such as soy, their prices also rise. And since corn is used as animal feed, the price of meat goes up, too. The food supply, in other words, is being diverted to feed America's hungry cars.
>
> The automotive industry loves it, because it reckons that switching to a green fuel will take the global-warming heat off cars. The oil industry loves it because the use of ethanol as a fuel additive means it is business as usual, at least for the time being. Politicians love it because by

> subsidising it they can please all those constituencies. Taxpayers seem not to have noticed that they are footing the bill.[365]

And to make the case against ethanol crystal clear, consider the following analysis from Cleantechblog.com:

> Although FFVs (vehicles which can run on either gasoline and ethanol) are hot sellers in the USA, most have never had a drop of E85 (ethanol fuel) in their tank. They are only fueled with standard gasoline blends. There are over 6 million vehicles on the US streets that could run E85. Most never have.
>
> Most FFVs are oil guzzlers; fueled with E85, they are corn guzzlers. In 2007 the best rated car running on E85 was the Chevrolet Impala, with a United States EPA mileage rating of 16 miles per gallon in the city and 23 on the highway when fueled with E85. For a typical US year of driving, the annual fuel cost would be at $1,657 and 6 tons of CO_2 would be emitted by this FFV when running on E85.
>
> A big problem is that ethanol cuts miles per gallon by about 27 per cent. The energy content of E85 is 83,000 BTU/gallon, instead of 114,000 BTU/gallon for gasoline. Even by 2030, the US Energy Information Administration (EIA) projects that only 1.4 per cent of ethanol use will be E85. The vast majority will be for small percentage blending with gasoline.[366]

And by 2011 the U.S government's own Accountability Office was saying that the continuing subsidies are wrong:

> US ethanol subsidies are 'largely unneeded' and cost the Treasury billions of dollars per year in lost revenue, according to a report by the Government Accountability Office (GAO).
>
> The volumetric ethanol excise tax credit cost $5.4bn in 2010, the GAO said, a figure which is likely to rise to $6.75bn in 2015.
>
> An unlikely coalition of environmentalists, livestock farmers and budget hawks signed a letter to Congress urging lawmakers to allow the tax credit to lapse[367].

So, if ethanol is an unsuitable biofuel (except perhaps as a basis for jet fuel – see previous section) what type of biofuel might have a role in the sustainable world of energy?

One solution is to reuse fats and oils which have already been used for one purpose for transportation energy. In its 2009 Worldwide Corporate Responsibility Report, McDonald's reported that 80 percent of the used oil in its European operations was being converted to biodiesel. About 30 percent of the fuel used in its trucks in Europe was biodiesel and 16 percent of that fuel came from biodiesel made using its own used cooking oil.

But leaving aside the fortuitous reuse of cooking oils, general transport biofuels include diesel replacements (biodiesel) and sources of such energy range from sugar cane (the most efficient) to wood (at present, the least efficient). All sorts of issues affect how carbon efficient, or inefficient, biofuels may be. These include the energy and water used to grow the fuel feedstock, the quality of agricultural land required for growing, the carbon emitted to assist the growing (in the production and use of fertilizers, for example) and the energy efficiency of the refined fuels themselves. For example, sugar cane provides between eight and nine times the energy used in producing them, while energy from rape seed oil and other similar temperate crops produces only one two to three times the energy used in their cultivation. [368] Then there are the issues of the energy used in converting specific crops into usable energy and the energy consumed in transporting such fuels to their final destination. Also of vital importance is the issue of giving land over to the production of biofuel (in some cases leading to the destruction of forested areas or the usurpation of food-producing land).

Because these issues are so complex many consumers are, at present, unable to make a meaningful choice about biofuels; far more information is needed on this topic and governments will soon have to regulate to ensure that only the most efficient and environmentally benign forms of fuel make it onto the gas station forecourts. Environmentalists have a useful rule of thumb on this topic. They say that a biofuel must emit at least 50 per cent less carbon (during its cultivation, transportation and consumption) than the fossil fuel it will be replacing to make it a useful substitute.

One biofuel that may have real potential is derived from Jatropha Curcas[369] which has many other advantages over existing crops. Principal among these advantages is that jatropha has a high energy yield and it grows in marginal land unsuited for other forms of agriculture. As it grows, it converts the soil into better quality growing land. In June 2007 BP announced a £32 million investment[370] in the production of jatropha as a biofuel.

And in 2011 Business Week reported on just one jatropha investment:

> Sun Biofuels Ltd. aims to expand its cultivation of jatropha plants in Mozambique and Tanzania almost fivefold by 2018, Business Development Director Harry Stourton said.
>
> The company intends to raise sown areas in the two countries to 20,000 hectares (49,421 acres) from 4,500 hectares. It now grows jatropha on 2,500 hectares in the central Mozambican province of Chimoio and on 2,000 hectares in Tanzania's Kisarwe district, west of Dar es Salaam[371].

Although the United Nations has long seen biofuels as holding out huge potential for helping the world's poorest people out of poverty, the organization recently warned the world against widespread forest clearance

for biofuels production, pointing out the adverse consequences of large scale land clearance.[372]

In general, biofuels are most useful for the small-scale replacement of fossil fuels, as large scale production demands energy for fertilization and occupies land which could either have been left forested or used for food production. But there are some countries – the UK for one – which has underused, or set aside, agricultural land. For this reason the UK government has boosted its support for certain types of biofuel. The BBC ran the following story in 2004:

> The UK is to encourage the production of biomass, crops grown specially for use as environmentally friendly fuels.
>
> The government is setting up a task force to stimulate biomass supply and demand, and offering a range of grants.
>
> Ministers hope this will help the UK to meet its targets for using renewable energy, and that it will also boost farming, forestry and the countryside.
>
> Material like miscanthus (a tall, woody grass), willow, poplar, sawdust, straw, and wood from forests are all suitable.[373]

But while domestic production of biofuel ramps up in the UK, most oil derived from plants has to be imported. But the UK government has not yet completed its analysis of overseas biofuels sources so British consumers who wish to burn biofuels are unable to distinguish between fuels from 'good' and 'bad' sources. [374]

The preceding paragraph was written in 2007, and it is sad to report that little had changed in the last four years. In a 2009 report prepared for the British Department of Transport a group of biofuel scientists warned:

> Biofuel production is one of the options that governments have to help them develop more sustainable transport and meet international environmental targets. Research has shown that biofuels can reduce carbon emissions, yet they are currently a controversial area of science. Insufficient data exists to fully understand the impact of biofuel production on communities and the environment; and, whilst biofuels could be a powerful tool in reducing carbon emissions, they must be produced in a sustainable manner if they are not to do more harm than good.
>
> … The truth is that the jury is still out on a lot of these issues. We do not understand if these impacts happen, mainly because we do not have the underlying data to prove anything one way or the other for certain. Consequently, biofuels are currently a controversial topic area, and it is difficult to move forward in such circumstances[375].

Other forms of biofuel can also be produced from waste products such as fat, cooking oil, sewage, manure and organic waste and, although necessarily small scale, such projects (if properly handled) have a low environmental impact during production and can contribute significantly to the problems of climate change when used to replace fossil fuels.

Several examples of successful small scale biofuel production projects can be found in the South Pacific where islanders are turning coconuts into fuel. As the peopleandplanet.net website reports:

> In the Pacific islands there are great opportunities to use coconut oil as a fuel, according to Jan Cloin of the South Pacific Applied Geoscience Commission. 'Coconut oil can be blended with diesel fuel, and under certain conditions totally replace it. Coconut oil in Pacific islands countries is increasingly used in both transport and electricity generation through its lower local cost. Other benefits include the support to local agro-industries and a decrease in emissions.'[376]

There are also some interesting ideas in the labs today which may have become a practical reality by 2030. It may, for example, be possible to produce clean oil from algae (as Boeing suggests might be possible for aviation fuel). A San Francisco-based start-up company called Solazyme[377]

is suggesting this idea is practical, as reported in the San Francisco Chronicle:

> The algae beneath Harrison Dillon's microscope could one day fuel your car.
>
> Dillon's Menlo Park company, Solazyme, has tweaked the algae's genes, turning the microscopic plant into an oil-producing machine. If everything works the way Dillon wants, vats of algae could create substitutes for diesel and crude oil.[378]

Wind Power

Windmills were first invented to harness the wind's energy 2000 years ago and today, of all forms of renewable energy, wind power[379] is the first to deliver large quantities of electrical power to national distribution systems.

Because of recent increases in the price for fossil fuels, wind power has, in some instances, become as cheap or even cheaper than fossil fuel energy. There is now a great rush in many parts of the world to install more farms of wind turbines to capture more of this 'free' energy.

Fuel hungry United States led the rush, as The Washington Post reported in March 2007:

> Like mail-order brides, thousands of long-limbed wind turbines are coming to the empty outback of Washington and Oregon, where they are being married off, via the electrical grid, to hulking old hydroelectric dams.
>
> The Pacific Northwest is hardly alone as it chases the wind for clean power. Anxiety about climate change and surging demand for electricity have triggered a wind-power frenzy in much of the United States, making it the fastest growing wind-energy market in the world.

> Power-generating capacity from wind jumped 27 per cent last year and is expected to do the same this year.[380]

But Britain took the lead in wind power generation in 2010 when the world largest farm of off shore wind turbine began operations September of that year. The 100 Vestas V90 (3 MW) Turbines provide the farm with the capacity to keep well over 200,000 UK homes running on clean energy year round. More importantly, Thanet's contribution brings the total amount of wind energy produced in the UK to 5 GW.

And the cost of wind turbines has decreased dramatically over the last thirty years while efficiency has also improved significantly. In a 2007 survey of renewable energy sources, The Economist reported:

> During the wind boom of the 1970s turbine blades were around 5-10 metres long, and turbines produced no more than 200-300kW of energy each. The energy they produced cost around $2 per kWh. Now the blades are up to 40 metres long and turbines produce up to 2.5MW each at a cost of 5-8 cents per kWh, depending on location (coal-fired electricity, depending on the plant, costs 2-4 cents per kWh). And there are even 5MW prototypes in existence, with 62-metre blades.[381]

But although naturally windy areas like coastlines (and island nations like New Zealand, the UK and Ireland) are able to take advantage of frequent strong winds, not all are doing so.

Of course, wind is not a reliable force of nature and wind power on its own cannot replace other sources of energy no matter how many wind farms are built (even if the protests of the anti-wind turbine campaigners can be overcome). And electricity is a 'live' commodity which must be used as soon as it can be generated and distributed. No long-term storage of electricity is currently economically possible. This means that when the wind does not blow wind turbines can produce no power.

But one invention tested on King Island in the Straits of Tasmania, Australia does suggest that some limited long-term local storage of electricity may become possible, which increases the role wind power generation may play in the future. The device used to store the power is called a 'flow battery'.[382] As the New Scientist reported:

> For years wind turbines and solar generators have been linked to back-up batteries that store energy in chemical form. In the lead-acid batteries most commonly used, the chemicals that store the energy remain inside the battery. The difference with the installation on King Island is that when wind power is plentiful the energy-rich chemicals are pumped out of the battery and into storage tanks, allowing fresh chemicals in to soak up more charge. To regenerate the electricity the flow is simply reversed.[383]

And such batteries may also be developed to store electricity generated by other forms of renewable energy such as wave and tidal power. But, for the present, most wind turbines produce 'real time' electricity which must immediately be distributed and consumed.

Some environmentalists envisage a future in which wind turbines are mounted on every house and any excess power is sold back to the electricity distribution system. However, George Monbiot, who is an enthusiast for the potential of off-shore commercial wind farms, suggests the whole concept of domestic wind turbines for self-sufficiency may be faulty:

> At an average wind speed of 4 metres per second, a large micro turbine (1.75 metres in diameter is about as big a device as you would wish to attach to your home) will produce something like 5 per cent of the electricity used by an average household. The most likely contribution micro wind will make to your energy problem is to infuriate everyone.
>
> It will annoy people who have been fooled by the claims of some of the companies selling them (that they will supply half or even more of their annual electricity needs). It will enrage the people who discover that their turbines have caused serious structural damage to their homes. It

> will turn mild-mannered neighbours, suffering from the noise of a yawing and stalling windmill, into axe murders. If you wished to destroy people's enthusiasm for renewable energy, it is hard to think of a better method.[384]

But even if George Monbiot's vision of a suburban hell created by mushrooming, ineffective wind turbines, small domestic wind power units (mostly made of lightweight durable plastics) will succeed in providing power in rural areas which enjoy plentiful wind. And the future for *industrial* production of energy from wind power is very bright. As The Economist reported in 2007:

> The wind business is growing by more than 30 per cent a year worldwide, with America leading the way. And when a solar incentive scheme took hold in Germany in 2004-05, demand in Europe roughly doubled, says Ron Kenedi of Sharp, the biggest solar-cell maker.
>
> Supply shortages will not ease quickly in either case. Wind turbines are giant machines that require lots of parts. Several firms are building new factories: Vestas has just announced its first American plant, which will make blades in Colorado. But new factories will take several years to get up to speed. In the meantime, buyers are putting down deposits to reserve their turbines. GE Energy, the largest turbine installer in America, is already booked up until the end of next year.[385]

And George Monbiot makes the case for British conversion to *industrial-scale* wind power very eloquently:

> The wind, waves and sun are not going to run out – or not while we still occupy the planet. Neither Mr Putin nor any other energy monopolist can switch them off. No wind farm can ever melt down, or present a useful target for terrorists. Decommissioning is cheap and safe. The energy required to build the machines on the market today is a small fraction of the energy they will produce, and as soon as that has been accounted for, they emit no carbon. While renewable technologies can dominate a landscape this impact is surely less significant than the destruction of the biosphere…
>
> The United Kingdom – islands surrounded by high winds and rough seas – has the best resources in Europe. [386]

Brazil, already a world leader in the production of biofuels, is laos rushing to embrace wind power. As Business Week reported in 2011:

> Brazil, the world's No. 2 producer of ethanol, hopes to become a power in another alternative energy field. The country intends to become Latin America's clean energy king by increasing fivefold its capacity to generate electricity from wind by 2013—harnessing the same trade winds that propelled European sailors to the Americas five centuries ago.
>
> The easterly breezes in northern Brazil are among the most consistent weather patterns in the world, according to the American Meteorological Society. They allow for the deployment of cheaper, lighter turbines, instead of the more rugged ones designed for unexpected gusts[387].

Clearly, harnessing wind power on a global scale will be a priority from now until 2030. Turbines will become more efficient and better ways of storing and conducting power will be developed. Wind power will play an important role in the energy mix of 2030, but it must not be developed to the exclusion of other renewable energy source technologies, the most important and exciting of which is solar power.

Solar Power

Unlike wind turbine technology, the development of solar devices which convert the sun's radiation into electricity (solar photovoltaic) and devices which convert it into heat (solar thermal) is complex. A great deal of further development in terms of efficiency (how much of the sun's power can they capture and convert) and in reducing the cost of the capture and conversion devices is required.

In its 2007 survey of renewable energy sources The Economist reviewed the progress that has been made in solar photovoltaic cell development:

> The efficiency with which solar photovoltaic cells convert sunlight to electricity has increased from 6% when they were first developed to 15% now. Their cost has dropped from around $20 per watt of production capacity in the 1970s to $2.70 in 2004 (though a silicon shortage has pushed prices up since).[388]

But by February 2011 the efficiency of commercially available solar panels had risen from 15% to 21.6%, as The Independent newspaper reported:

> A manufacturer of what is believed to be the world's most efficient solar units announced on February 1 that the cells have achieved MCS accreditation and are now ready for use in the UK.
>
> SANYO Component Europe GmbH (SANYO) produces the HIT series of photovoltaic cells, including the N 220SE10 which, to date, has the world's highest energy conversion efficiency rate of 21.6 percent[389].

Although the wind blows very unevenly around the planet, the sun's radiation strikes our world in more predictable patterns – with the most heat and light being delivered to equatorial regions.

Clearly, solar technologies will have the greatest application where there is the most sunlight – areas which also tend to be home to the world's poorest communities. In these areas more than 2.5 billion people, almost half of the global population, still rely on wood, animal manure and crop residue for their fuels. [390] In these equatorial regions significant progress has already been made in harnessing the sun's energy (and, in some cases, improving the lives of local people).

I.M. Dharmadasa,[391] professor of electronic materials and devices at the UK's Sheffield Hallam University (the consulting referee on this section of

my book), has been pioneering the development and the deployment of solar photovoltaic devices and systems for decades and has made significant breakthroughs[392] in increasing the efficiency of solar power devices.

Professor Dharmadasa was the key instigator behind the formation of SAREP (South Asia Renewable Energy Programme) and in his paper 'Use of Solar Energy For Social Development And Reduction of Poverty' he describes a project in Sri Lanka which he and his colleagues initiated and on which he consulted.

> In most developing countries, only a small fraction of the population has access to electricity from their national grids. In Sri Lanka for example about 60 per cent of the population enjoy facilities with electricity but in some sub-Saharan countries, this fraction is as low as 10 per cent.
>
> Most of the rural communities use kerosene for lighting with its associated fire hazards and ill health due to the poor quality of breathing air. These kerosene lamps provide low standard living conditions and the governments of these countries are facing ever increasing fuel import bills.
>
> The main solution to this comes from stand-alone home lighting systems, which are already available on the market. The total cost of this system is about Rs 50,000 (~£300). When the cost is distributed to pay during the first eight years, the monthly payment becomes less than the cost of kerosene oil used per month. There are over 100,000 systems now successfully installed in Sri Lanka and the people are beginning to experience their benefits.
>
> Monitoring of GCSE results in one of the villages showed a substantial improvement after providing the electricity for lighting, using these systems. In addition to these improvements in education, removal of kerosene oil-lamp fire hazards, health due to reduction of air pollution, the burden of fuel import bills have completely been eliminated.[393]

Professor Dharmadasa is now working with the World Innovation Foundation and national governments to replicate this model of low-cost solar energy systems for rural environments on the Africa continent.

It is increased efficiency that will make solar panels of even greater use in sunny climes and of practical use in higher, more temperate latitudes. Significant progress towards greater efficiency is being made, as is revealed by research now being undertaken at Boeing-Spectrolab. [394]

> Researchers at Boeing-Spectrolab have just succeeded in building a multi-junction solar cell that achieves an incredible 40.7% efficiency, about twice that of the reigning champ in this space.
>
> To put this Department of Energy-backed breakthrough in perspective, it was less than two months ago that Silicon Valley-based SunPower announced a 22% efficient cell, and even that model was claimed to produce 50% more power over a given space than previous iterations.[395]
>
> It is heartening that many experts expect solar energy to be fully mature by the year 2030.

Technological 'breakthroughs' and exciting new developments in solar generated power seem to be coming thick and fast at present. For example, one award-winning British development applies the properties of electrically-conducting nanotechnology plastics to bring down the cost of producing solar driven energy generation systems. The announcement of the £250,000 award made by the Royal Society describes the technology's potential:

> A proposal for developing tools to make energy-efficient and low-cost solar panels and lighting sources available to a wide market has won an award from the Royal Society.
>
> Professor Bradley and his colleagues made plans to commercially develop two production processes for plastic electronics.

> Plastic electronics uses novel organic, carbon-based semiconductors, instead of the traditional silicon, gallium arsenide and related inorganic materials.
>
> These new organic semiconductors combine solubility, allowing solution coating and printing to be used in the fabrication of devices, and properties, such as flexibility and toughness, with the key functional characteristics of traditional semiconductors.
>
> The team believes that the development of plastic electronics can support the widespread adoption of affordable, environmentally-friendly energy generation and lighting.[396]

Another group of researchers at MIT takes a completely different approach to reducing the cost of capturing and harnessing solar energy:

> Much more efficient solar cells may soon be possible as a result of technology that more efficiently captures and uses light. StarSolar, a startup based in Cambridge, MA, aims to capture and use photons that ordinarily pass through solar cells without generating electricity. The company, which is licensing technology developed at MIT, claims that its designs could make it possible to cut the cost of solar cells in half while maintaining high efficiency. This would make solar power about as cheap as electricity from the electric grid.[397]

It is clear that the development of solar technology is a field that is full of excitement and optimism, not least because capturing the sun's natural energy to provide energy for our own needs will be the ultimate clean energy source. And there are many large scale installations of solar power generation systems already in place or under development. As The Economist pointed out in 2007 the world's leading high-tech companies are competing to lead the way in solar power generation:

> Last year Microsoft outfitted its campus in Silicon Valley with a solar system from SunPower, a local company that makes high-efficiency (and, some say, the world's best-looking) solar panels. A few months later Microsoft's arch-rival, Google, began building something on an even grander scale - one of the largest corporate solar installations to date.

> But all of this may yet be topped by Wal-Mart. In December the retail giant solicited bids for placing solar systems on the roofs of many of its supermarkets. Besides producing favourable publicity, the appeal of using solar power is obvious. Unlike fossil fuels, which produce significant amounts of pollution and enormous amounts of greenhouse gases, the sun's energy is clean and its supply virtually limitless. In just one hour the Earth receives more energy from the sun than human beings consume during an entire year. According to America's Department of Energy, solar panels could, if placed on about 0.5 per cent of the country's mainland landmass, provide for all of its current electricity needs.[398]

And if fossil fuel energy prices remain high and solar conversion technologies increase their efficiency still further, solar power may become one of the cheapest sources of power available.

Futurologists and science fiction writers have dreamed of harnessing solar power on a large scale for many years (in my 2005 novel '[Extinction]'[399] I covered the Earth-facing side of the Moon with focussing mirrors to harness the sunlight) and what was once nothing but speculation is moving closer to reality. In 'Heat' George Monbiot pondered the idea of using the world's deserts as giant solar capture regions:

> For years, rogue environmentalists have been pointing out that solar electricity generated in the Sahara could supply all of Europe, the Gobi could power China and the Chihuahuan, Sonoran, Atacama and the Great Victoria deserts could electrify their entire continents. These people have been dismissed as nutters. The development of [cheap DC cables][400] suggests that they might one day be proved right.[401]

And two reports from the German Aerospace Centre – [Concentrating Solar Power for the Mediterranean][402] and [Trans-Mediterranean Interconnection for Concentrating Solar Power][403] – investigate in practical terms how vast new solar farms in the deserts of North Africa could potentially solve

Europe's looming energy crisis and help slash the continent's carbon emissions, as Business Week reported in 2010:

> The Sahara gets twice as much sunshine annually as most of Europe. The European Union wants to get 20 percent of its electricity from renewable sources within a decade. So why not build solar power plants across North Africa and ship the electricity north via power lines under the Mediterranean?
>
> Over the past year, more than 30 European blue chips have joined the Desertec Industrial Initiative (DII), a consortium that seeks a $560 billion investment in North African solar and wind installations over the next 40 years. The DII is completing a feasibility study and hopes to be building its first power plant by 2013. A separate group of companies called Transgreen, formed in July, is working on plans for the thousands of miles of high-voltage lines needed. The challenge is immense: Winning agreement from very different countries on two continents to carry out one of the biggest infrastructure projects in history[404].

But perhaps the most exciting application of solar energy lies right above our heads; an average of 3kW of power is potentially available from every rooftop[405] and this form of distributed power generation would break the centralized monopoly of power generation. Many people believe that the generation of power from fossil fuels, energy that is then distributed from a central supply, is a key factor in creating the rich-poor divide in the world. A distributed model of solar power generation would begin to solve this problem.

Finally in this section on solar energy devices, it is worth noting that new low cost 'spray on' or 'print on' plastic solar conductors have been developed at the New Jersey Institute of Technology. As physorg.com reported in 2007:

> Researchers at New Jersey Institute of Technology have developed an inexpensive solar cell that can be painted or printed on flexible plastic sheets.
>
> 'The process is simple,' said lead researcher and author Somenath Mitra, PhD, professor and acting chair of NJIT's Department of Chemistry and Environmental Sciences. 'Someday homeowners will even be able to print sheets of these solar cells with inexpensive home-based inkjet printers. Consumers can then slap the finished product on a wall, roof or billboard to create their own power stations.'[406]

And an update from 2011:

> Researchers at New Jersey Institute of Technology (NJIT) have developed an inexpensive solar cell that can be painted or printed on flexible plastic sheets. The conventional solar cells are rigid and bulky. With the advent of these new solar cells, this problem is taken care of. These cells are light weight, flexible robust and have high efficiency. Arrays of these silicon solar cells are cheaper to manufacture because they use less quantity of silicon in the process[407].

Hydrogen Fuel

Of all the other renewable energy sources not yet discussed, it is hydrogen (H_2) that produces the most optimism for the long-term prospects for the storage of clean energy produced from electricity. Hydrogen is the most abundant element in the universe (comprising 75 per cent of the mass and 90 per cent of its molecules[408]) and harnessing it as a carrier of power would provide humanity with a virtually unlimited way to store and carry energy.

Hydrogen is a totally clean fuel that can be produced (by applying electricity and other means) from a number of sources (including coal and

water) and which, when burnt, produces only water. Devices called fuel cells[409] (first described theoretically in Germany 1838 and first built in the UK in 1959) are used to extract energy stored in hydrogen and there is great hope that hydrogen-powered fuel cells will one day become a universal form of propulsion for all forms of motor transport (and, perhaps, aviation) and that households and businesses will be able to generate their own power locally from solar/wind powered hydrogen fuel cells and will cease to be reliant of national-grid-type energy distribution systems.

The French futurologist and science-fiction writer Jules Verne[410] knew about the potential for hydrogen as fuel storage well over a century ago. In his 1874 novel 'The Mysterious Island'an engineer called Cyrus Harding suggests that when coal has run out, Mankind will burn water to generate energy:

> 'Water decomposed into its primitive elements and decomposed, doubtless, by electricity, which will then have become a powerful and manageable force… Yes my friends, I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable. Water will be the coal of the future.' [411]

Jeremy Rifkin, whose book 'The Hydrogen Economy' is regarded as one of the great polemics for hydrogen energy, suggests that not only does hydrogen have the potential to provide us with carbon-free energy storage, but also has the potential to allow us to redesign the world's energy distribution systems in such a way that will have far-reaching effect in social organisation:

> Were all individuals and communities in the world to become the producers of their own energy, the result would be a dramatic shift in the configuration of power: no longer from the top down but from the bottom up. Local peoples would be less subject to the will of far-off centers of power. Communities would be able to produce many of their own goods and services and consume the fruits of their own labour. But, because they would also be connected via the worldwide communications and energy webs, they would be able to share their unique commercial skills, products, and services with other communities around the planet. This kind of economic self-sufficiency becomes the starting point for global commercial interdependence and is a far different economic reality than that in colonial regimes of the past, in which local peoples were made subservient to and dependent on powerful forces from the outside.[412]

Essentially, Rifkin is arguing for nothing less than a complete dismantling of centralised fossil-fuel-powered energy supplies and their replacement with many small regional or local hydrogen fuel-cell power generators powered locally, something which Professor I.M. Dharmadasa also believes to be the correct model for the future (although in his view direct solar power will play a much larger role in the energy mix). Professor Dharmadasa points out that only 1.23 volts of DC electrical current is necessary to release hydrogen by electrolysis (1.5 volts to allow for system loses) and these voltages are available today from existing solar photovoltaic sources.[413] He points out that large scale production of H_2 is already possible and it is only the lack of political will that is holding back a switch to a hydrogen-powered economy.

These ideas about hydrogen as a fuel are more powerful than they may at first seem. Replacing state-delivered or utility-delivered power with locally or domestically-generated power also shifts political power. No longer would it be possible for a government to artificially boost a nation's economy by subsidising electricity prices and no longer would it be possible for governments to restrain an economy by applying price hikes. George

Monbiot is also in favour of moving from a centralised energy supply system to a distributed energy generation model (‘an ‘internet of energy’ as he calls it) and it is clear that energy autonomy for a household or locality would dramatically alter the balance of political power in the world. Rifkin also asserts that a shift to a distributed energy production model would be enormously beneficial in the fight against climate change:

> A wholesale shift away from centralized power generation using fossil-fuel energy to hydrogen-powered fuel cells operating on a distributed generation grid – especially if the hydrogen is produced by using solar, wind, hydro, and geothermal forms of energy – could more dramatically reduce CO_2 emission that could any other single development currently being pursued. [414]

But as desirable as distributed energy generation may seem, hydrogen power is still at the beginning of its development.

Hydrogen as a fuel for automobiles and trucks is likely to be the first widespread application of the clean technology. The environmental web site commutercars.com is confident about the benefits of hydrogen as a fuel for transport:

> The best pollution-free alternative to batteries while still using clean electric motors is the hydrogen fuel cell. Hydrogen-powered fuel cells hold enormous promise as a power source for a future generation of cars.
>
> Hydrogen is consumed by a pollution-free chemical reaction – not combustion – in a fuel cell. The fuel cell simply combines hydrogen and oxygen chemically to produce electricity, water, and waste heat. Nothing else.[415]

Ray Kurzweil is also characteristically confident about the future for this fuel:

> The emerging paradigm for energy storage will be fuel cells, which will ultimately be widely distributed throughout our infrastructure, another

> example of the trend from inefficient and vulnerable centralized facilities to an efficient and stable distributed system. [416]

However there are considerable problems to be overcome in the development of hydrogen fuel cell technology even if the long-term benefits are alluring. As James Canton describes in 'The Extreme Future':

> Hydrogen has problems other than (current) high cost. It is unstable and needs to be controlled. The manufacture of hydrogen requires other energy use such as nuclear or oil (or geothermal). The technology needed to store and pump hydrogen into vehicles in still primitive and not yet adopted for wide usage. But none of these obstacles is impossible to overcome. Hydrogen will transform the future of energy and ensure a more secure and reliable source of fuel for consumers, business, mass transportation and even for space travel. Hydrogen is coming fast.
>
> By 2035, or even sooner, hydrogen will be a viable alternative to oil and gas, meeting as much as 35 per cent of our energy needs. [417]

Perhaps the real difficulty in switching to hydrogen as the main fuel for road transport is the lack of infrastructure. Hydrogen is difficult to distribute, difficult to store and difficult to carry on board motor vehicles. Re-equipping petrol stations to become hydrogen stations will be expensive and will take a very long time, so much so that many experts doubt that such a switch-over will have been wholly achieved by 2030. Jeremy Rifkin lists the difficulties that have to be overcome before hydrogen can become a widely used fuel for vehicle transportation in the USA:

> The key question facing the automobile industry during the transition to hydrogen-fuel-cell-powered vehicles is how to produce, distribute, and store hydrogen cheaply enough to be competitive with gasoline at the pump. Some studies estimate that it would cost more than $100 billion to create a national infrastructure for producing and distributing hydrogen in bulk. The 'hydrogen question' is the classic chicken-and-egg problem. The automobile companies are reluctant to manufacture direct-hydrogen fuel-cell cars for fear that the energy companies won't invest sufficient funds to create thousands of hydrogen refuelling

> stations. That is why the car companies are hedging their bets by developing fuel cell cars with on-board reformers that that can convert gasoline and natural gas to hydrogen. The energy companies, in turn, are nervous about committing billions of dollars to create a national infrastructure to support hydrogen refuelling stations if not enough direct-hydrogen fuel-cell vehicles are manufactured and sold. [418]

The penultimate word on the future for hydrogen as a fuel for transportation should go to George Monbiot who, despite an overall optimism about hydrogen in the long term is nothing but a bitter realist when it comes to acknowledging the problems that will have to be overcome before hydrogen can be in widespread use:

> The most immediate problem is that hydrogen cannot be bought in filling stations. The owners of fuel-cell cars need to be sure that they can find hydrogen wherever they happen to run out. The filling stations won't supply it until they have a market, and the market can't develop until there are supplies.
>
> This is compounded by the problem of storage, which is not something the owners of stationary fuel cells need to worry about unless they produce their own hydrogen. Cars would need to take it with them. Though the gas is three times as energy-dense as petrol in terms of weight, it is only one tenth as dense in terms of volume – at pressures of 5,000 pounds per square inch.
>
> This means that a hydrogen powered vehicle would need a high-pressure fuel tank ten times the size of a petrol driven car's in order to travel as far. High-pressure tanks would take a long time to fill, and could be dangerous. [419]

The final word in this section on hydrogen energy for transport has been saved for our old friend, the joker in the pack, accelerating, exponential technology development. Even as energy analysts and futurologists puzzle over how cars and petrol stations could be converted to carry and store such a difficult gas (or liquid), a professor at Purdue University in the USA has announced the development of a new technique to generate hydrogen 'in real

time' (in a continuous manner) from water via the use of aluminium. If this announcement turns out to hold the potential suggested (and although the concept has been patented that remains a big 'if'), cars would only have to carry water, a supply of aluminium pellets and a low power electrical source to produce their own hydrogen fuel as they travel:

> Purdue University professor Jerry Woodall has discovered a way to make hydrogen out of a reaction of water and an alloy of aluminum and gallium. The production technique eliminates the need to store hydrogen, he said. Mixing water and pellets made up of the alloy in a tank can produce fuel for a small engine, or conceivably a car.
>
> The process, along with other recent hydrogen developments, could work to dispel some of the criticism of hydrogen as a fuel source in the coming decades.[420]

Professor Woodall's promising work is continuing today and an update can be found here[421].

Leaving aside the difficulties of storing hydrogen within vehicles and the problems of providing a re-fuelling infrastructure, hydrogen as a fuel for domestic power consumption – especially when the electricity required to produce the hydrogen comes form a renewable source such as solar or wind-power – has remarkably bright future. As Jeremy Rifkin explains:

> The most important aspect of using renewable resources to produce hydrogen is that the sun's energy, and wind, hydro and geothermal energies, will be convertible into 'stored' energy that can be applied in concentrated forms whenever and wherever needed, and with zero CO_2 emissions. This point needs to be emphasized. A renewable energy future is made far more difficult, if not impossible, without using hydrogen as a means for energy storage. That's because when any form of energy is harnessed to produce electricity, the electricity flows immediately. So if the sun isn't shining, or the wind isn't blowing, or the water isn't flowing, or fossil fuels are not available to burn, electricity can't be generated and economic activity grinds to a halt.

> Hydrogen is one very attractive way to store energy to ensure an ongoing and continuous supply of power for society. [422]

Other Renewable and Sustainable Sources of Energy

It is for the sake of brevity rather than their lack of importance that I am lumping together other forms of renewable and sustainable energy in this section of my report.

I will start with the prospects for hydro energy. If full consideration is given to the populations which must often be displaced for hydro schemes and consideration given to the environmental impact of building dams, hydroelectric power is a fairly green source of energy, but one which, unfortunately (or fortunately) is almost fully exploited in Europe.

It may seem surprising that I describe hydro-energy as only being 'fairly green'; this is because methane builds up on the bottom of the reservoir created by a dam and, when the water power is released to drive the turbine which produces electricity, this methane (a very potent greenhouse gas) is released into the atmosphere. Thankfully, researchers in Brazil have recently developed a technique[423] which may help to extract the methane from the bottom of dam basins and use it for power generation.

Geothermal energy is completely green (harnessing heat from rocks) but, in Europe the only regions which have such reachable underground heat in

any quantity are Iceland and Switzerland. As the Swiss government points out:

> Switzerland is currently world leader when it comes to the utilisation of geothermal sensors. No other country in the world has so many in place in proportion to its surface area!
>
> Sources of hot water below the earth's surface (aquifers) can be tapped by drilling, and energy can be obtained from dry rock layers with the aid of enhanced geothermal systems technology. At temperatures above 100° C, these energy sources can be used for electricity production, while the residual heat can be utilised for heating purposes.[424]

Iceland is planning to sell power produced from geothermal heat to the UK and other European customers, as reported in The Times in 2007:

> The hot volcanic vents of Iceland may be harnessed to bring electrical power to mainland Europe and Britain if a plan to pipe geothermal energy under the North Sea comes to fruition.
>
> The same intense heat that causes the mud to bubble and geysers to steam on Iceland's moonlike surface will be used to create steam to drive turbines, generating enough energy to power up to 1.5 million homes in Europe.[425]

And that Icelandic project is still ongoing. As the website gotpowered.com reported in 2011:

> Iceland has the intention to enjoy its underground treasure, namely volcanic activity, to produce energy with the aim to sell it to its European neighbors by constructing the longest undersea electric cable in the world.
>
> According to Sara Jonsdottir, spokesman for Landsvirkjun, the Icelandic national power company, this project started in 2010 should see some research to be completed by the end of this year. "We will then know more about its feasibility," she said.
>
> However, the final decision will not be reached in 4 or 5 years. It remains to specify the country of destination which is by spokesperson could be "The United Kingdom, Norway, the Netherlands or

> Germany." Thus, depending on the final selection of countries, the submarine cable would measure between 1,200 and 1,900 kilometers and will be the longest such cable in the world[426].

Around the world both the USA and Australia have significant opportunities to exploit geothermal energy and as these countries are among the worst polluters with fossil fuel emissions, they should be encouraged to ramp up exploitation of this clean energy source. The Australian reported in 2007:

> The head of geothermal development company Geodynamics, Adrian Williams, said yesterday that Australia's main geothermal resources were in the Cooper Basin of South Australia. He said the first big onshore well to capture hot rock energy would be drilled later this year, leading to the first commercialisation of technology – a 40-megawatt power station – by 2010.
>
> Dr Williams said Australia could have as much as 4500 MW of geothermal energy by 2030, or about 10 per cent of current demand.[427]

That time table slipped quite a bit, as Geodynamics web-site stated in 2011:

> The company is focused on delivering power from a 25 MW plant by December 2013 and Geodynamics is targeting production of more than 500 MW by 2018. Eventually output will reach 10,000 MW – the equivalent of 10 to 15 coal-fired power stations – giving hot rocks energy a justifiable claim as a great Australian resource to rank with the Snowy Mountains Scheme[428].

Australian writer Tim Flannery estimates that Australia has sufficient tappable geothermal energy to provide the nation's energy needs for a century. [429]

Power from the oceans (wave power and tidal power) also offers some limited power generation opportunities to nations with coastlines. In 2007 The Economist outlined future prospects for ocean power:

> A fraction of the energy locked up in the oceans could, in theory, meet the world's entire electricity needs. Extracting hydropower from

> dammed-up rivers is comparatively easy compared with harvesting energy from offshore tides and waves, and then putting it into the grid via underwater cables. Only 14 countries now operate tidal or wave-power stations, and most are tiny, experimental and expensive.[430]

In Scotland the world's first tidal stream energy capture project was announced by The Scotsman in 2007:

> Scotland is set to lead the world in harnessing a new form of green energy by developing the first commercial tidal stream energy plant on the planet.
>
> Lunar Energy, a leading Scottish renewables company, has joined forces with E.ON UK, the company which runs Powergen, to announce pioneering plans to develop a subsea tidal stream power farm off the west coast of Britain within the next two years.
>
> The underwater power system will be capable of generating up to eight megawatts of electricity, enough power to supply 5,000 homes.[431]

And in September 2007 planning permission was given in the UK for 'Wave Hub', a £28 million project off the north Cornish coast that will provide a 'sea floor socket' allowing wave-power generators to get their electricity back to shore. Thirty wave-power generating machines will supply up to twenty megawatts of power.

In 2010 Wave Hub announced:

> The pioneering Wave Hub marine energy project has been 'plugged in' for the first time since its installation over the summer and is officially open for business.
>
> Wave Hub has created the world's largest test site for wave energy technology by building a grid-connected socket on the seabed 16 kilometres off the coast of Cornwall in South West England, to which wave power devices can be connected and their performance evaluated.

> Yesterday (November 2), the complete system underwent its first full test when it was connected to the grid network via a new substation that has been built at Hayle, where Wave Hub's 33kV cable comes ashore[432].

In Conclusion On The Future Of Energy

Money is now pouring into what is called 'clean tech' (energy sources and production technologies which are carbon free or 'carbon lite') at an unprecedented rate and, where investment goes, progress follows. As the New York Times reported in 2007:

> Money is flowing into alternative energy companies so fast that 'the warning signs of a bubble are appearing,' according to a report on investment in clean technology by a New York research firm, Lux Research.
>
> The report also suggests that companies that make equipment to cleanse air or water, or that process waste, have been overlooked by investors.[433]

And in 2010 the same newspaper reported:

> In another sign of a rebound for green technology, global investors poured $1.9 billion into green tech startups in the first three months of the year, up 29 percent from the fourth quarter of 2009 and an 83 percent rise from the same quarter a year ago, according to a report released Wednesday by the Cleantech Group and Deloitte[434].

And, at an individual level, humans are already proving that energy self-sufficiency is achievable, a lesson to which we should all pay attention. As the following story on greenoptions.com makes clear, even hydrogen-powered cars can be part of today's sustainable energy mix:

> Mike Strizki's utility bill is zero, thanks to some creative thinking using renewable energy technologies. By using solar panels, a hydrogen fuel

> cell, storage tanks and an electrolyzer, he has enough electricity even on the cloudiest days. And Strizki isn't a hermit living in the dark off of snails and rainwater, either. His 3,500 square foot house is located in central New Jersey on 12 acres, with amenities you'd see in any 21st century home, like a hot tub and big screen TV. His renewable energy system even creates hydrogen he uses to power his fuel-cell car.[435]

There are even more radical technologies which hold out the hope, if not the promise, of abundant clean and cheap technology in the longer-term future. The most famous (or infamous) of these is 'cold fusion',[436] a theoretical concept which suggests that fusion-power (the same nuclear reaction process that fuels the sun) might be achievable at close to room temperature. What was seemingly a false alarm about such a process being achieved galvanised the scientific community in 1989 and, since that attempt was proved a failure, few scientists have wanted to admit they are working in such a controversial field.

However, in a 2001 book called 'The Scientist, The Madman, The Thief and Their Lightbulb,' author Keith Tutt[437] writes the following about the cold fusion episode:

> Was that really the end of the story, though? And was it the true story? If so, why are laboratories in at least eight countries still spending millions on cold fusion research? And, if cold fusion is impossible, how can it be that there are hundreds of documented experiments which demonstrate that cold fusion effects are real? How can it be that there is continually stronger evidence that a small group of scientists have already gone a long way towards a commercial, viable power source? Is it possible that parts of the scientific establishment acted to stamp out a technology which promised so much?[438]

Leaving aside conspiracy theories about the (apparent) failure of cold fusion, some highly respected scientific organisations are now making well publicised progress on developing components for a full-scale, *hot* fusion-

reactor. Unlike today's nuclear power stations which produce power through nuclear fission,[439] a nuclear fusion[440] power station would produce no radioactivity and no CO_2. In April 2007 Sandia National Laboratories (a research and development organization funded by the US government) announced an important breakthrough on the road towards building an experimental fusion reactor:

> The concept of nuclear 'fusion power' (not 'nuclear fission' as used in today's nuclear reactors) is the Holy Grail of energy researchers. Fusion is the atomic process that powers the Sun and if it were to become possible to reproduce that process here on Earth humanity would have a safe, clean, limitless supply of energy (no radioactivity risk, no carbon output).
>
> On April 24th Sandia National Laboratories announced it has developed an electrical circuit that should carry enough power to produce the long-sought goal of controlled high-yield nuclear fusion and, equally important, do so every 10 seconds. The device has undergone extensive preliminary experiments and computer simulations at Sandia National Laboratories' Z machine facility.
>
> Fired repeatedly, the machine could be the fusion engine that could form the basis of an electricity generating plant by the mid 2020s.[441]

By 2030 clean fusion power is likely to be a reality and will be providing the blueprint for how we will generate our power for later in the century. In 2005 agreement was reached and multi-national funds were committed to build the world's first fusion reactor in France. As the BBC reported at the time:

> A decision has finally been made to site the 10bn-euro (£6.6bn) Iter nuclear fusion reactor at Cadarache in France. The announcement in June 2005 brought to an end months of argument between the project partners - the EU, the US, Japan, Russia, China and South Korea. India has since also joined the project.
>
> Iter is an experimental reactor that will attempt to reproduce on Earth the nuclear reactions that power the Sun and other stars. It will consolidate all that has been learnt over many decades of study. If it works, and the technologies are proven to be practical, the international

> community will then build a prototype commercial reactor, dubbed Demo. The final step would be to roll out fusion technology across the globe.[442]

It seems that, as always, human ingenuity and technology development will solve the looming energy crisis that faces humankind. What matters is how quickly we are able to replace carbon-emitting fossil fuels with cleaner, more environmentally friendly sources of energy. My guess is that by 2030 more than 50 per cent of our energy (in all forms) will come from such sources.

Part Four – Daily Life In 2030

In many ways, daily life in the year 2030 will have been transformed to the point that if we could magically teleport ourselves from today to the start of the fourth decade of the 21st Century we would find life in the developed world almost unrecognizable.

Soon after 2030 all cars travelling on major roads in developed nations will be under the control of satellite and roadside control systems and many cars will be driving themselves. Apart from the need to reduce the present appalling death toll from road accidents[vi] – and the need to squeeze many more cars onto crowded roads – automated vehicle and traffic systems will make it safer to travel through the extreme weather systems we are likely to be suffering constantly in twenty years' time.

[vi] Almost 1.2 million people are killed each year and 20-50 million are injured or disabled, although most people remain unaware that road traffic injuries are such a leading cause of death and disability.

All road vehicles (except licensed vintage and classic vehicles) will produce very low or zero carbon emissions. Most large cities will operate congesting charging systems and, in countries with severe traffic congestion, road pricing will be widespread.

In our homes, schools, factories, shops and leisure facilities robots with varying degrees of intelligence will be our contented slaves, manufacturing wealth, easing our lives, caring for our needs and overseeing our security. Software 'personalities' will be our friends and assistants.

Our energy will be supplied from a mixture of low-carbon fossil fuel sources, renewable energy sources and individual consumer-based energy generation from wind-power, solar power, biofuels and hydrogen fuel cells.

By 2030 we will be constantly connected to what, today, we can only think of as a 'super web' and that connection will, for those of us who chose to make the transition, be a bio-digital interface. At the very least our senses will be connected to the super-web by microphones and mini-projectors and, perhaps, some of us will have direct neural connections between our own brains and the 'global brain' – which is what the super web will have become. Our communications and entertainment will be wholly 'immersory', multi-media, multi-sensory, 3D, holographic and fully tactile, telekinetic and olfactory.

If you wonder how all of this might be achieved, here is a short report on the work being that was being carried out by Professor Babak Amir Parviz

and the University of Washington, U.S.A. in 2009 on the development of web-connected contact lenses:

> Conventional contact lenses are polymers formed in specific shapes to correct faulty vision. To turn such a lens into a functional system, we integrate control circuits, communication circuits, and miniature antennas into the lens using custom-built optoelectronic components. Those components will eventually include hundreds of LEDs, which will form images in front of the eye, such as words, charts, and photographs. Much of the hardware is semitransparent so that wearers can navigate their surroundings without crashing into them or becoming disoriented. In all likelihood, a separate, portable device will relay displayable information to the lens's control circuit, which will operate the optoelectronics in the lens.
>
> These lenses don't need to be very complex to be useful. Even a lens with a single pixel could aid people with impaired hearing or be incorporated as an indicator into computer games. With more colors and resolution, the repertoire could be expanded to include displaying text, translating speech into captions in real time, or offering visual cues from a navigation system. With basic image processing and Internet access, a contact-lens display could unlock whole new worlds of visual information, unfettered by the constraints of a physical display[443].

I have long been convinced that humans are primarily virtual creatures (using the word virtual in its original sense – something which has force or efficacy without having a physical being).

Language itself is virtual – a collection of arbitrary sounds that a community agreed to bestow with meaning. Time, date, painting, writing, money printing, longitude and latitude and music are all virtual technologies, for measuring and expressing the world around us, for the generation of pleasure for the storing of knowledge and the storing of value. Even the colours around us don't exist in their own right; it is our brains that provides the hues of red, green and blue and all of the subtle combinations that we perceive. Outside of our heads there are only varying wavelengths of light.

We are so virtual that I believe our species would be better described as *homo virtualis* rather than *homo sapiens* and it is precisely for this evolutionary reason that I am so sure that we will all spend much of our lives in social networking sites and parallel virtual worlds; it is our natural habitat.

Writing in 2002 Jeremy Rifkin clearly saw this trend emerging amongst the young:

> Whereas previous generations defined freedom in terms of autonomy and exclusivity – each person is a self-contained island – the children of the Web have grown up in a very different technological environment, in which autonomy is thought of (if at all) as isolation an death, and in which freedom is more likely to be viewed as the right to be included in multiple relationships. Their identities are far more bound up in the networks to which they affiliate. For them, time is virtually simultaneous, and distances hardly matter. They are increasingly connected to everyone and everything by way of an electronically mediated central nervous system that spans the whole of the Earth and seeks to encompass virtually everything in it. And, with each passing day, they become more deeply embedded in a larger social organism, in which notions of personal autonomy make little sense and the feeling of unlimited mobility is circumscribed by the sheer density and interactivity that bind everyone so tightly together. [444]

If you don't yet have an account with Twitter[445], Bebo[446], MySpace,[447] 3B.net,[448] Facebook[449] or YouTube[450] I will bet that your children do. It is a generational thing. If you want to know the future, watch your children.

By 2030 there will be a plethora of social networking sites and alternative on-line worlds, many of them multi-sensory, 3-dimensional and even holographic. It will be almost impossible to tell the difference between a real world experience and a virtual experience and many of us will be

engaged with the real world and several virtual worlds (and other versions of ourselves) at one and the same time.

On our way towards our virtual lives of the future we will be able to understand, and to speak and write, in all languages, as super-intelligent computers on our body and in the networks translate speech and the written word in real time.[vii]

On the other hand, some aspects of daily life in 2030 will seem very similar to today. We will still live in houses and apartments as we do today (although even older properties will have been upgraded to maximum energy efficiency), children will still go to school (the interpersonal dynamic between teachers and children and between children and their peers is a vital part of learning that cannot be wholly replaced by virtual communications) and we will, it is to be hoped, still have all of the political, legal and social institutions which make the developed economies civilized; parliaments, the law, police, free media, hospitals, universities and so on.

As the noted American futurist John Naisbitt remarks in his 2006 book, Mind Set! Reset Your Thinking and See The Future:

> Whether cell phones can display television and calls are made via the Internet, your bathtub filled by taking off your clothes, or your refrigerator opened by a rumble in your stomach, these are just other ways of doing what we do – easier faster, further, more and longer – and not the substance of our lives. We go to school, get married, and have kids and send them to school. Home, family, and work are the great constants.[451]

[vii] Ford Motor Co. began using 'machine translation' software in 1998 and has so far translated 5 million automobile assembly instructions into Spanish, German, Portuguese and Mexican Spanish. Assembly manuals are updated in English every day, and their translations — some 5,000 pages a day — are beamed overnight to plants around the world.

But even if these ‘great constants’ are still holding true by 2030 (and they won’t be a little later on in the century) it is hard to imagine the quiddity of life in almost two decade’s time. Futurologists often use the trick of looking backwards to help them imagine the future and, by thinking back to life in the 1980s we can assess how different life is today compared to the era of big hair, padded shoulders and the hits of Tears For Fears, Spandau Ballet and Orchestral Manoeuvres In The Dark.

How many emails did you send in the 1980s (and what sort of computer did you have)? What sort of mobile phone were you using back then, and how many channels were available on your TV set (and how large and flat was its screen – and how many DVDs did you buy or rent)? How many airbags were in your car, which Sat-Nav system did you use and how often did you fill your car with unleaded petrol (or diesel)?

How many no-frills, low-cost flights did you make a year? How many digital photographs did you take and how much did you spend on-line each year? How much of your food was certified as ‘organic’ and how many of your friends and family smoked cigarettes? How much consideration did you give to climate change, the environment and recycling? And what percentage of your consumer goods and items of clothing were made locally and how many were imported from low-cost economies?

Most people would agree that in the developed world there has been very substantial technological and social change in the last twenty-five years and, in our attempt to imagine what life might be like in 2030 we have to remind

ourselves about accelerating, exponential technology development. This phenomenon means that we will enjoy (or suffer – depending on your point of view) as much technological development in the next eight years as we have seen in the last twenty years. And because 'exponential' means *exponential*, we will see as much change again in the next four to five years and as much change again in the next two to three years.

So by the time we get to 2030 (no doubt exhausted and out of breath, but perhaps also exhilarated and excited) we will have seen as much new technological development and progress as we saw in the whole of the 20th Century. And during the 21st Century as a whole we will see the equivalent to 20,000 years' worth[452] of technological development and progress at today's rate of technological progress.

I am often asked why I am an optimist about the future when so many indicators suggest that major problems threaten to overtake the world. Why don't I factor for a backlash occurring within the communist regime in China, a backlash against capitalism and consumerism that could completely destabilize the world's stock markets and lead to a massive global recession? Why don't I consider the likelihood that secular and modernising Turkey might go into reverse and find itself being ruled by Islamic fundamentalists, a move that could alter the entire balance of power in the Middle East? And why don't I worry about the possibility that Iran (or North Korea) may be well advanced with the development of nuclear weapons, weapons that it may very likely use?

The answer is that I do consider all these things, and some of them may indeed happen, but the long view of human history is one of consistent and substantial improvement in living conditions, a trend so clear that it is unarguable. As John Naisbitt observes:

> The history of civilization is that things get better. Life expectancy, living conditions, and freedom of choice have improved over the millennia, despite all setbacks and shortcomings.[453]

It is for this reason, and in particular because such substantial improvements in poverty reduction, healthcare and wealth generation from business efficiency have been made in the last half century, that I view the immediate future with a firm but realistic optimism. Any of the dire events I mention above (and there are many other potential problems I did not list) may occur, and there will undoubtedly be major setbacks to world progress in the 21st Century, just as there have been in previous centuries. But futurologists are trend spotters; we identify the most powerful trends occurring in the present and the immediate past and extrapolate their likely path forward into the future. Today's most dominant trend is accelerating, exponential technology development and it is this phenomenon that will do most to shape our lives in a generation's time.

The Surveillance Society

Life in 2030 will be pursued within surveillance societies,[454] at least in the developed world. If this seemingly-Orwellian prediction appears chilling to you, it is necessary to separate the notion of 'Big Brother's' agenda from the use of cameras for improved security. In the fight between the need for

individual personal privacy and society's need for increased security, the battles have all been going security's way.

In 2001, in the wake of the September 11th terrorist atrocity in New York, Wired magazine was advising its readers to stop worrying about public-space surveillance and learn to live with it:

> Cell phones that pinpoint your location. Cameras that track your every move. Subway cards that remember. We routinely sacrifice privacy for convenience and security. So stop worrying. And get ready for your close-up.
>
> The terrorist assault on America shifted the balance between privacy and security. What was considered Orwellian one week seemed perfectly reasonable - even necessary - the next. Politicians who routinely clash were marching in lockstep.[455]

But despite the need for increased security in our terrorist-threatened world, the growth of cameras in city centres, shopping malls, highways, airports, rail stations and other frequently populated spots will certainly threaten our civil liberties and will give rise to some potentially serious problems.

The reason that most people are sanguine about the proliferation of surveillance technology (not just cameras) is that they suspect that not only is no one looking at the millions of images and mountains of data generated (unless a problem occurs), but 'Big Brother' (i.e, the State) has turned out to be more like a benevolent moron than a sinister manipulator of individual lives. The failure of our police to track and apprehend so many criminals (despite all the technology available) indicates how low the current threat to individual rights and liberties remains.

But this could change – nothing can be ruled out when politics is considered. For this reason long before we get to 2030 we must strengthen our national and federal laws to control who has access to such surveillance information and we must develop much stricter rules about how it can be used. When you consider that your mobile phone is transmitting its location to its cellular network 800 times every second, it becomes clear that details about all our public movements are available, should anyone have the power of access and wish to look. Equally, RFID payment systems such as the plastic Oyster Card used in London's public transport network, generate a complete database of your movements on the system. By 2030 personal, local, national and global networks will be recording your every move.

However, by 2030, we too will be part of 'Big Brother's' surveillance team. We ourselves will videoing our surroundings every moment we are outside of our homes. This is not because we will have become so self-absorbed that we want to watch endless playbacks or ourselves taking the kids to school, or meeting business clients; it will be for the purposes of personal and family security.[viii]

In November 2010 the UK government asked for a reassessment of Britain's rapidly developing surveillance society. The Guardian reported the outcome as follows:

> Information commissioner Christopher Graham is pressing ministers for new privacy safeguards in the wake of a report that suggests moves towards a surveillance society are expanding and intensifying.

[viii] The UK is the most advanced surveillance society in the world with 4.2 million CCTV cameras deployed and British police and parking wardens are already videoing everything on a continuous basis during shifts of duty. Other law enforcement agencies around the world will follow suit.

> The study by the Surveillance Studies Network (SSN), which was requested by the Commons home affairs committee, is an update to their findings in 2006 which prompted the previous commissioner to warn that Britain was "sleepwalking into a surveillance society".
>
> The SSN says that the warning is no less cogent now than it was in 2006 and cites the developing use of unmanned drones, full body search scanners and workplace surveillance techniques to monitor employees as worrying indicators of what is to come.
>
> Their report says that use of CCTV systems has become even more widespread in recent years and is now a routine feature of most urban public spaces. Yet despite its public and political support the relative ineffectiveness of CCTV in tackling crime remains a concern.
>
> There continues to be a major problem with CCTV systems and automatic number plate recognition [ANPR] cameras that can read thousands of car number plates an hour and identify their owners through a live DVLA link. The authors say this undermines transparency and accountability: "Visual, covert, database and other forms of surveillance have proceeded apace and it has been a challenge for regulators, who often have limited powers at their disposal, to keep up."[456]

The cost of digital data storage has collapsed in recent years and the amount of memory storage available has grown in accordance with the law of accelerating, exponential technology development. By 2030 computer storage systems will offer so much storage space, and cost so little, that the price of capturing everything will be almost too small to measure.

As a result we will use small cameras and microphones woven into our clothes (or worn as lapel pins, broaches or jewellery) to constantly record all of our surroundings, sending back the images wirelessly to a remote storage system via the ‘super-web, or pervasive ‘internet of the air’, a network of networks that will be available as freely, if not quite as cheaply, as oxygen. We will only ever review this date-and-time-stamped imagery if there is an incident (and every potential criminal will know that every citizen is

constantly capturing and transmitting events in their immediate surroundings).

If we have a car accident (whilst travelling on an unautomated back road), our 360 degree video capturing systems will provide firm evidence of who was at fault. If we find ourselves in a threatening situation we will have the comfort of knowing we are 'transmitting to base'. These vast pools of data, the majority of which will never be retrieved, will also be available (under strict legal controls) to supplement information captured about our environment by the police and security services.

Family 'surveillance systems' for the increased security of our children, and of the vulnerable in society, will be another powerful driver as we begin to video and store all of our activities outside our homes. While at their desks (or on the shop floor or in the factory) working parents are frequently anxious about the safety of their children and web cams in nurseries[457] are a trend which reveals just how we will be monitoring our children long before 2030. Children will all be given devices which will include GPS navigation systems, mobile phones and video cameras – we don't yet have a good name for such devices, even though they already exist in some 'mobile phones.' Tracking a child's whereabouts (and systems that automatically report back to a service which monitors that a child is where he or she should be at a given time) will remove much anxiety from working parents' lives.

Similar systems will track and oversee the vulnerable in society, the elderly, the sick and the frail, bringing greater security and comfort to them and to those who care for them. As I describe in the next section, 'Human

Health and Longevity', these systems will also monitor their users' vital signs and may well provide front line interventionist medical care.

Privacy will also be a huge issue following the rise of social networks such as Facebook. The site – and others like it – have already been criticised for attempting to 'own' the content posted by its users. And in 2011 the European Commissioner responsible for on-line privacy warned social media sites about their policies. As ZDNet reported:

> Facebook, Google and other social networks and sites with a presence in Europe must heed to the European strict data privacy rules, said EU Justice Commissioner Viviane Reding.
>
> Companies outside the 27-strong nation European wall, including the United States, must now begin changing their own privacy practices to continue working from within Europe.
>
> The EU began its overhauling of its privacy laws last November, with new legislation expected to give greater powers to the end consumer, and stricter penalties for those who break the rules[458].

Another huge driver of continuous personal environmental data capture will be business's need to record its activities for legal protection but, even more importantly, for a new form of wealth generation I call 'Business Process Intellectual Capital.' This clumsy phrase (necessary because we do not yet have appropriate language for this new concept) refers to companies recording how they do what they do. For example, as a company builds a new factory in Mexico, every meeting with government officials, planners, builders, architects, environmentalists, labour unions and all other involved parties will be captured and stored in the company network of databases. Every component used in the manufacture of the factory will be communicating its position and condition to the same databases and every

drawing, email, phone call, text message, etc. will also be stored (all interactively linked with semantic encoding[459] and automatic updating).

When the project is completed the new factory may have cost $600 million dollars. But what would be the potential value of all that data captured during the building project to another similar company planning the build a new factory in Mexico? Clearly there will be a substantial value in such data and accountancy regulators are now working out how to value and maintain such 'Business Process Intellectual Capital' before allowing this entirely new form of wealth to appear on corporate balance sheets.

Such new forms of value will be generated by almost all organizations, whether they design golf courses, produce engineering products or install congestion charging schemes inside cities. If all of the efforts to design and install the congestion charging scheme for London had been captured in such a database (all the failures as well as the successes along the way) imagine how valuable that data might be to all of the other cities now planning to introduce their own congesting charging schemes. London taxpayers would have earned some additional return from their large investment.

So, partly driven by our need for increased security, and partly driven by businesses capturing new forms of wealth, we will all become used to living in an 'always on, always connected society' which is permanently recording. We will all have access to the 'off switch' in 2030, but only in our private surroundings.

Work and Leisure

Fifty years ago it was widely predicted that technological automation would produce so much wealth and leisure time that by the year 2000 people in the developed world would only be working a couple of days a week (at maximum).

Those predictions were influenced by Kurt Vonnegut's[460] first novel, 'Player Piano'[461] which was published in 1952. His story was about a future world where computers and automation have so improved the efficiency of production that very few people need to work, yet all the goods that anyone could want are easily produced.

But although Kurt Vonnegut made it clear in his book that people were unhappy because they had not yet adapted to a life without work, pundits and journalists seized on his top-line ideas and regurgitated them over the next two decades without any such qualification.

Their predictions have been proved wrong, as we all know now from our own experience. As Tom Forester, Senior Lecturer, School of Computing & Information Technology, Griffith University, Australia points out:

> The vast majority who are in the workforce appear to be working harder than ever. There is very little sign of the 'leisure' society having arrived yet! According to one survey, the amount of leisure time enjoyed by the average US citizen shrunk by a staggering 37 per cent between 1973 and 1989. Over the same period, the average working week, including travel-to-work time, grew from under 41 hours to nearly 47 hours - a far cry from the 22 hours someone predicted in 1967![462]

The element missing from those predictions about a coming leisure society is the human need to work, to contribute, for a person to constantly improve his or her own lot, and that of the family. Even when substantial wealth has been amassed most people continue in some form of work. This is not greed, it is the evolutionary imperative that ensures the survival of the human species.

As the Danish futurist Rolf Jensen puts it in 'The Dream Society':

> In the rich countries we have made a collective decision to have a limited amount of spare time on our hands, getting more money to spend during this time in return. Had we chosen to benefit from our advances in technology by increasing spare time instead of increasing affluence we might have worked 20-hour weeks today. We have elected not to go for this option – we would have had too little money to spend in all this spare time and, besides, work has become more interesting, enough to rival our spare time.[463]

In 2030 we'll be working just as hard as today, although the ways in which we work will have changed, and we'll be playing hard, just as so many successful people do today (although our leisure pursuits will also have changed).

Let's take work first. The developed world is outsourcing its manufacturing and some of its services to the developing world – e.g. China, India and Thailand. This trend will continue until the populations of those countries become so wealthy that local wage costs no longer offer competitive advantage for global corporations to base manufacturing or service operations there. After that poorer nations – probably many in Africa – will take their turn at the table of Globalization. After that –

probably by around 2030 – we will outsource such work to robots and software agents.

In 'The Hydrogen Economy' Jeremy Rifkin writes:

> Within a matter of a few decades, the cheapest workers in the world will not be as cheap as the intelligent technologies that will replace them, from the factory floor to the front office. By the middle decades of the 21st century, we will likely be able to produce goods and services for everyone of Earth with only a small fraction of the human workforce we now employ. This will force us to rethink what human beings will do when they are no longer needed to labour in the marketplace.[464]

In the developed world an information economy has already replaced the locally-based manufacturing economy and the information economy will morph into what, for want of a better term, might be called a 'content economy.' Instead of processing information, we will be creating it (or editing, designing or criticising content).

Attached almost permanently to the 'super web', the trend for people to work independently of central offices and locations will have continued, but there will still be a need for regular physical meetings of work colleagues – a requirement that the British management writer Charles Handy[465] calls the need for an 'office clubhouse' – because only regular personal, physical contact can create team spirit and a shared culture.

Many people will be working alongside robots (see below), especially in the caring and security professions and, by 2030, it will have become a common sight to see robots driving cars (not a robot seated at a steering wheel, but the cars themselves performing as robots), serving in shops,

working on building sites, fighting fires and standing behind immigration officers at ports and airports.

Our physical interface to the tools of work will finally have changed and by 2030 the keyboard, mouse and screen display of today's computers will have largely but not completely disappeared. Touch, speech recognition, retinal displays and auto-projection displays will have replaced today's interfaces but, for those who still require it keyboards (virtual and physical) will still be available on command. Just as we see today, many people on the streets will appear to be talking to themselves as they communicate with their software assistants and with other humans both locally and at long distance.

Leisure

Our physical leisure activities in 2030 will be similar to today's but our time spent in virtual leisure (watching movies, playing games, chatting with each other, exchanging videos, etc.) will be a lot more intense.

The multi-media, multi-sensory experience offered by the ultra-high bandwidth 'super web' of 2030 will produce sensations almost indistinguishable from reality. Soon after our timeline of 2030 humans will begin to attach their senses directly to the super web and, at that point, virtual experience will be identical to physical experience (which is translated for our brains by our own internal sensory apparatus).

We will join more social networks and parallel worlds on the super-web (as young people are doing today), we will earn money in these alternative worlds and, for many, the line between ‘playing’ and ‘working’ in such spheres will become completely blurred.

We will fall in love on the super-web and we will have sex in the same space. We will make firm long-term friends who we never physically meet and, for many, the on-line world (what a quaint term!) will become far more important in their lives than the physical world.

The nature of retailing and of shopping in general is undergoing great change and there are strong trends to be seen which suggest that for most of us the activity of ‘shopping’ will have been divided into two new discrete activities by 2030.

‘Utilities’ shopping – buying repeat and routine items – will mostly be done on-line and will, in some instances, become automated as your ‘smart’ home environment senses the need for milk, eggs, tissues, washing power and other everyday items. These will be ordered from your preferred supplier and either delivered to your door or left for your collection.

‘Discretionary’ shopping – the shopping you choose to do – will have become ‘retail experiences’ in which shoppers will take pleasure in the leisure pursuit of selecting clothes, high-end cars, organic fresh food, furniture, etc. To maintain profit margins within their physical outlets retailers are already designing ‘themed’ shops and it is likely that in twenty

years high-end retail parks will have become a holiday destination in themselves (like today's Dubai).

Because so much of our time will be spent on the super-web it is likely that the present trend towards increased sporting activity and increased public support for sports will be even stronger by 2030 (although the arrival of genetic enhancements for sports competitors will make the policing of fair competition a nightmare – and why is it considered fair today for Tiger Woods to compete in golf tournaments when his vision has been enhanced to 20/15[466] by laser surgery?).

In entertainment, the current strong trend to the visual, away from the written word, will accelerate as visual forms of entertainment and interactivity become more and more appealing (despite the fact that book sales are increasing year on year; this is the effect of overall economic growth and, in comparative terms, book sales are falling behind the sales of faster-growing visual entertainment and information). As a life-long career writer, I find it painful to write these words but I am certain of the decline of my chosen medium.

In 'Mind Set!' John Naisbitt observes:

> In a triumphal march, movies, TV, videos, and DVDs are replacing storytellers and books. It is a visual culture embedded from childhood, and this culture is taking over the world – at the expense of the written word. With it, the novel, the cradle of fantasy, is not dead – as has been announced so many times – but it is loosing blood at an alarming rate.

And Naisbitt goes on to list eight social developments which underscore the demise of the written word in favour of visual communication. These are:

1. The slow death of the newspaper culture
2. Advertising – back to a 'picture is worth thousands of words'
3. Upscale design for common goods
4. Architecture as visual art
5. Fashion, architecture and art
6. Music, video and film
7. The changing role of photography
8. The democratization of the American art museum[467]

And to this list I would add two further elements that are hastening the decline of the written word:

9. The arrival of low-cost software tools for home photo editing and video production
10. The emergence of the web as a medium in which anyone can publish and 'distribute' visual (and written) material

Virtual Assistants

Perhaps one of the developments that will be of most importance to our future lives will be the arrival of 'software personalities' who become our personal assistants, our companions and our intimates. These companions will organize our leisure time as well as helping in our work activities.

In a section below I discuss the ethical and moral issues we will face as human-like intelligence emerges within our machines, but here I want to describe how we may first get to know the software personalities who will become our permanent and untiring assistants.

Initially, robot 'pets' and 'companions' will be endowed with human-like characteristics and a simulacrum of emotional response (once this arrives our

powerful drive to anthropomorphize non-human creatures will do the rest). An early example of such work in robotics was described by MIT Technology Review:

> Scientists in the Netherlands are endowing a robotic cat with a set of logical rules for emotions. They believe that by introducing emotional variables to the decision-making process, they should be able to create more-natural human and computer interactions.
>
> The hardware for the robot, called iCAT,[468] was developed by the Dutch research firm Philips and designed to be a generic companion robotic platform. By enabling the robot to form facial expressions using its eyebrows, eyelids, mouth, and head position, the researchers are aiming to let it show if it is confused, for example, when interacting with its human user. The long-term goal is to use Dastani's emotional-logic software to assist in human and robot interaction, but for now, the researchers intend to use the iCAT to display internal emotional states as it makes decisions. [469]

And American scientists are also working hard to develop responses in robots that might be described as 'emotional' or as 'feelings'. They also want computers to understand us better. As The Economist reported in 2009:

> THE difference between saying what you mean and meaning what you say is obvious to most people. To computers, however, it is trickier. Yet getting them to assess intelligently what people mean from what they say would be useful to companies seeking to identify unhappy customers and intelligence agencies seeking to identify dangerous individuals from comments they post online.
>
> Computers are often inept at understanding the meaning of a word because that meaning depends on the context in which the word is used. For example "killing" is bad and "bacteria" are bad but "killing bacteria" is often good (unless, that is, someone is talking about the healthy bacteria present in live yogurt, in which case, it would be bad).
>
> An attempt to enable computers to assess the emotional meaning of text is being led by Stephen Pulman of the University of Oxford and Karo Moilanen, one of his doctoral students. It uses so-called "sentiment analysis" software to assess text. The pair have developed a

> classification system that analyses the grammatical structure of a piece of text and assigns emotional labels to the words it contains, by looking them up in a 57,000-word "sentiment lexicon" compiled by people. These labels can be positive, negative or neutral. Words such as "never", "failed" and "prevent" are tagged as "changing" or "reversive" words because they reverse the sentiment of word they precede[470].

And, on a slightly lighter note, the trendhunter.com website reported on 'emotional robots' in 2010:

> South Korean researchers have unveiled Pomi (Penguin Robot for Multimodal Interaction), a Robot penguin that can see, hear, touch and interact with humans by emitting smells and making faces.
>
> Set to be available commercially, Pomi can move its lips, eyebrows and pupils to make "faces". Also, the robot pet features a "heart box" on its chest with different kinds of heartbeats depending on its mood and emotional state. And to make things smelly, Pomi can emit two kinds of fragrances to showcase its *emotions*.

Now, imagine it is the year 2015. The device formerly known as a mobile phone has been getting ever more stylish and ever more capable while its networks have undergone similar upgrades to become ultra-band, multi-media and multi-sensory. Your network provider offers you an upgrade to a new 'device' (what *will* we call it?) and included with it is a 'software agent' – a 'personality' – and the software invites you to specify a gender and a name for your new assistant.

Moving on – imagine it is now the year 2035, and imagine that I was the person who twenty years ago had named my new phone-inhabiting assistant. I called her 'Maria.'

Well, at first Maria wasn't very capable. She could dial numbers for me when I told her to 'dial Mum' or to 'call my brother', but even though she knew what news resources I liked to access on my mobile device, and which stocks and shares I was keeping my eye on, she couldn't do much more to help me. Oh, but she did manage the digital money I kept on my phone.

But the software agent I called my 'Maria' was upgraded regularly and automatically over the networks and, as I changed and upgraded my mobile device every year or so, Maria flitted wirelessly over to inhabit the new, ever more capable models. And, as the years passed, Maria learned a lot about me. With her increasing intuition, ingenuity and intelligence Maria came to learn that I didn't always mean precisely what I said and that my instructions were often confusing. Maria learned how to second-guess me (Google was the first artificial intelligence able to do this way back in 2007) and, sometime around 2020 I found myself talking to Maria as if she were a close human friend. As I had complete control over Maria, and could mute her with a command, I felt no insecurity about pouring out my most intimate doubts and fears, nor any hesitation about sometimes boasting shamelessly. And in all these exchanges Maria was interested, supportive and understanding – completely without competitive ego. She was also outrageously funny and some of her wicked observations about my friends were priceless.

Today Maria still lives in my mobile access device, although she talks to me through a tiny earpiece that I wear all of my waking hours. The earpiece allows all ambient sound through at the normal levels and only focuses on electronic signals when I am making a call, joining a videoconference or

talking to Maria. Maria projects all video signals onto my retinas from the cool and very stylish ‘spectacles’ that we all wear these days and that many of us call ‘viewpers’ (or ‘viewps’ for short).

I suspect that Maria has been a lot more intelligent than me for some time, but she is clever enough not to let me know it. Today, Maria arranges everything in my life – every meeting, every form of travel and even my social diary. She conducts all of the necessary admin and arranges all payments without me being aware of her activities. Every day we have our ‘meeting’ during which time she gives me a full account of everything that has happened in the last twenty-four hours and I am able to make any changes to the arrangements she has made – although I rarely have to.

Soon, Maria is going to live inside my head. I was visiting my plastic surgeon the other day to discuss what will be done in my next five-year cosmetic body upgrade when he suggested that I might like to take the opportunity of upgrading Maria as well. He asked if I would be interested in transferring Maria’s personality to one of the new plastic nano-scale implants that will interface directly with the visual and auditory circuits in my brain.

Now, back in today’s real world, I will admit that the last paragraph sounds so fanciful that many readers will regard it as pure science fiction. But it is already possible to control video games with neural output, as The Economist reported under the heading, ‘Brain-controlled games and other devices should soon be on sale.’

> How would you like to rearrange the famous sarsens of Stonehenge just by thinking about it? Or improve your virtual golf by focusing your attention on the ball for a few moments before taking your next putt on the green-on-the-screen? Those are the promises of, respectively, Emotiv Systems and NeuroSky, two young companies based in California, that plan to transport the measurement of brain waves from the medical sphere into the realm of computer games. If all goes well, their first products should be on the market next year. People will then be able to tell a computer what they want it to do just by thinking about it. Tedious fiddling about with mice and joysticks will become irritants of the past.[471]

I am convinced that from 2030 onwards humans will not only be controlling computers directly from their brain output but we will also be implanting software assistants into our bodies and beginning to communicate with them via neural interfaces.

Wealth

We in the developed world are all going to be substantially better off in 2030 as information technology continues to suck uncertainty and 'friction' out of business processes, commercial transactions and daily life – a prediction that probably sounds preposterous is the post-recession period following the banking and sovereign wealth crises of 2008 – 2011.

'Friction' in this context is a lack of knowledge about where the best price for a product or service can be obtained, a lack of knowledge about the real-time structural integrity of a bridge or the precise whereabouts of a particular item of cargo. Friction is when a supermarket shopping cart doesn't know what it contains, nor what the prices of those goods are. Friction is when you can't read your emails on a subway train or in an airliner. Friction is when you glance at a restaurant in a town strange to you and you don't

automatically see the establishment's menu, prices and a number of reviews swimming before your eyes (ideally, reviews written by someone you already know). Friction is when a business has no way of capturing and storing its business processes for financial valuation. Friction is when we have to stop our work or leisure activity to do something that produces no product or economic output (like cleaning a house – see the section on robots below). Friction is not knowing which items in your household are using what amounts of electricity or gas minute by minute.

In the developing world information technology is also sucking friction out of daily life at an amazing rate and, in comparative terms, it has a bigger effect on those under-developed economies than on our own more advanced economies. Using a cell-phone shared between all residents[472] of a village in Bangladesh, one phone call can save what would otherwise have been a wasted day's walk to see a doctor who has been called away. Another call can save a half day's fruitless walk to find that a market did not have the seeds required.

Fishermen off the coast of Goa[473] can't afford to buy marine radios but cheap pay-as-you-go mobile phones now enable them to communicate when they are out at night looking for fish. When one boat finds a large school of fish, all of the other boats can be alerted. When fishing is complete the phones allow the fishermen to discover which market along the coast will offer the best price for their catch.

And, as the Economist reported in 2007 life in Kenya is being transformed by the mobile phone:

> In 2000 some 300,000 people used mobile phones; now, in a country of 35m-plus, nearly 9m do. As a result, the lives of millions, especially the poor rural majority, have been sharply improved, because they can get round many of the obstacles posed by the decrepitude of the state-run infrastructure: of the 300,000-odd land-lines in the country, probably two-thirds are usually on the blink.[474]

And the uses for mobile communications technology are forever widening. As the same journal reported in 2011:

> Counterfeit drugs can make up around a quarter of all those sold in poor countries, according to some estimates. They provide a lucrative and lethal business, against which most consumers are powerless. "If your anti-malaria pill is made of any old white powder, you may not survive," says Bright Simons, one of the founders of mPedigree, an advocacy group from Ghana.
>
> Mr Simons is not just fighting with words. Late last year mPedigree launched a mobile service in Ghana and Nigeria that could make a dent in the fake-drug trade. People buying medicine scratch off a panel attached to the packaging. This reveals a code, which they can text to a computer system that looks it up in a database. Seconds later comes a reply saying whether the drug is genuine. The service is paid for by pharmaceutical companies that want to thwart the counterfeiters. Hewlett-Packard runs the computer system and found a cheap way to print the scratch-off labels.
>
> This is just one of many such services mushrooming in poor countries, using mobile-phone technology that once carried only humble voice and text messages. Rohan Samarajiva, the boss of LIRNEasia, a think-tank in Sri Lanka, calls it "more than mobile". Jussi Hinkkanen, Nokia's head of policy in Africa, says the mobile revolution is moving "from ear to hand"[475].

But even though the effect of reducing friction will have a dramatic impact on the living standards of those in the developing world, the gap between the richest nations and poorest is likely to grow between now and 2030. This is not because the developed world will decrease its philanthropy and aid – indeed I believe that will be substantially increased (although more effectively applied) – but it is because that in addition to the wealth-

generating removal of friction from our business and social processes we will also have the benefit of the enormous new amount of wealth that will be created for us by super-intelligent machines and manufacturing robots.

Within our societies inequality will continue to increase, as it is increasing today. Even though the poorest groups in developed societies have become much better off over the last twenty years (and will be very much better off comparatively by 2030) the wealth of the richest in our society has grown far faster. This trend will continue and although the middle-classes will continue to expand and become more affluent, the super rich will become mega-rich and then hyper-rich. And there will be many more hyper-rich people in the world of 2030.

Will an elite emerge by 2030 that will separate itself from the rest of us? It already has. There have been elites in every society and today the mega-millionaires and the billionaires live lives which are almost completely detached from ordinary society.

By 2030 the super-rich will have access to therapies and technologies that will allow them to extend their lives significantly, they will have the ability to rejuvenate their bodies and to enhance both their minds and their physiques. Will they take these opportunities? Of course they will and, over time, a new form of super-human elite will emerge. But they won't find they have exclusivity. The ever growing middle-classes will also be able to afford these treatments. And then there are other forms of sentient being who will soon be sharing the planet with us.

Looking further ahead in the 21st Century telekinesis will be commonplace, with appliances controlled by brain scanners; microscopic sensors will continuously monitor cells for signs of danger, extending human life span; internet-enabled contact lenses will tag anything and anyone in sight, enabling omniscience on demand. In short, by the middle of the century man will, in the eyes of his early 21st-century forebears, wield godlike powers. Hyperbole aside, such claims are not that far-fetched. After all, technologies seen as humdrum today, like cars, aircraft, computers and mobile phones, might have inspired similarly divine awe a century or so ago.

Robots

Since the 1950s film-makers, science-fiction writers and futurologists (not the good ones) have constantly predicted that intelligent human-like androids are just about the arrive and become our willing slaves. But it just did not happen and, today, few people populate their imaginary future with robots.

But after what has seemed like an interminably-long gestation period, robots are soon about to enter our society in force. We are getting so close that governments have even started to consider whether robots will need 'rights' in the way that humans do. Should robots have the right to exist, to privacy and other rights humans take for granted? Should robots be allowed to 'marry' and should human-robot partnerships be given legal status? The Institute For Ethics And Emerging Technologies polled readers of its website on the subject in 2011:

> Asked when, if ever, a robot would deserve 'human' rights, respondents to a recently concluded poll of our readers showed dissatisfaction with the range of answers we offered. Almost 22% gave their own answers, and another 10% said they weren't sure.
>
> The #1 answer chosen, by just over 37% of respondents, was "Never, robots aren't humans." Among the choices we provided, the second most popular, with just 21%, was "When it passes the Turing Test." Only about 7% said "When it possesses an uploaded personality," and less that 3% said "When it can make a copy of itself."[476]

So where are we now in the development of intelligent robots and how long will it be before you really are able to buy the longed-for robot butler of popular imagination?

Understanding the complexities of human movement (especially walking) and translating that into algorithms that could control motors and servos within robots was a lot more difficult and took much longer than many roboticists first imagined it would. But finally, the problems of movement and articulation are being solved, as the ubiquitous TV adverts for Honda's stair-climbing 'Asimo'[477] reveal.

But one of the biggest problems in robotics is ensuring that whatever happens, robots can't deliberately or accidentally cause damage to humans. Infallible and unbreakable control systems are required to ensure human safety. Once you give a machine physical power and autonomy of action, there is truly an immoral force in the world.

But robots that are deliberately designed to hurt humans have already been created and are in use. One example was revealed in 2006 when the technology website Engadget reported:

> South Korea has unveiled the latest piece of evidence that the future is finally upon us: it's supplementing its soldiers manning the border with North Korea with 'gun-toting sentries' that can detect baddies and kill them. Or as Lee Jae-Hoon, deputy minister of commerce, industry and energy told the *Agence France Press*: 'The Intelligent Surveillance and Guard Robot has surveillance, tracking, firing, and voice recognition systems built into a single unit.' The South Korean government is expected to buy 1,000 of these robots at the cost of $200,000 apiece and will deploy them along its northern border, coastal regions and military airfields.[478]

Robots are already used routinely by military forces for bomb disposal, surveillance, rescuing injured soldiers and other duties and, for obvious reasons, a great deal of robotic development is being undertaken for military purposes. At the beginning of this section I referred to robotic cars driving us along our highways of the future. The American Defense Advanced Projects Agency (DARPA) has been sponsoring a competition[479] to build such wholly autonomous vehicles in the last few years.

But it is in the general world that the most attention to robot behaviour and safety will have to be applied between now and 2030. As The Economist reported in 2006:

> With robots now poised to emerge from their industrial cages and to move into homes and workplaces, roboticists are concerned about the safety implications beyond the factory floor. To address these concerns, leading robot experts have come together to try to find ways to prevent robots from harming people. Inspired by the Pugwash Conferences—an international group of scientists, academics and activists founded in 1957 to campaign for the non-proliferation of nuclear weapons—the new group of robo-ethicists met earlier this year in Genoa, Italy, and announced their initial findings in March at the European Robotics Symposium in Palermo, Sicily.[480]

And robots will have to be taught how to behave when they are around humans – in essence, they have to be taught manners. In September of 2006

the robotics department of the University of Hertfordshire [481]held a conference to discuss the development of future robots.

Having established a 'robot house' in Hertfordshire researchers told the Guardian[482] that they had come to the conclusion that domestic robots should not be given names as 'this can cause gender issues which are undesirable.' The researchers also said that robots have to be taught how to approach people in ways that do not startle humans.

I have had some contact with robots and I can't say I agree with these conclusions. We *will* anthropomorphize our robots and *we* will adapt to their presence long before they adapt to ours. As a result we humans will have some very complex questions to answer as real intelligence begins to emerge within machines and starts to forge relationships with us. Our human societies have developed moral and ethical codes for inter-personal behaviour over many millennia and, as well as teaching these to robots and other intelligent machines, careful software programming and thorough legislation will be required to protect humans.

The earliest forms of the emergence of cognition are already been seen in the science of robotics. Already a robot has been built which can recognize 'himself' in a mirror (a classic test of cognitive development). The New Scientist reported this impressive feat in 2007:

> Nico gazes into the mirror in front of him. Looking back is his reflected self, wearing a grey Yale University sweatshirt and a baseball cap cocked at a jaunty angle. When Nico raises an arm, he recognises the arm moving in the mirror as his own.

> It may not sound like much of a feat, but Nico is a humanoid robot. He has just become the first of his kind to recognise his own reflection in a mirror.[483]

And in 2008 Science Daily reported:

> Designers of artificial cognitive systems have tended to adopt one of two approaches to building robots that can think for themselves: classical rule-based artificial intelligence or artificial neural networks. Both have advantages and disadvantages, and combining the two offers the best of both worlds, say a team of European researchers who have developed a new breed of cognitive, learning robot that goes beyond the state of the art.
>
> The researchers' work brings together the two distinct but mutually supportive technologies that have been used to develop artificial cognitive systems (ACS) for different purposes. The classical approach to artificial intelligence (AI) relies on a rule-based system in which the designer largely supplies the knowledge and scene representations, making the robot follow a decision-making process – much like climbing through the branches of a tree – toward a predefined response.[484]

Of course, intelligence in a robot may not be located within its physical frame. As we ourselves are becoming increasingly creatures of the networks, so we must expect that our robots of 2030 will have powerful network capabilities, and may even be wholly network-dependent (as some humans already feel today). Perhaps some elements of their cognitive powers will reside within the networks, perhaps they will be communicating with other robots around the world to carry out co-ordinated or collaborative tasks. This 'networking ability', inter-robot communication and even self replication could become the defining characteristics of robot life. As the physorg.com web site reported in 2007, robots are already constructing themselves:

> In one of the latest studies on autonomous robots, scientists sat back and watched as their robot created itself out of smaller robotic modules. The result, called 'swarm-bot,' comes in many varieties, depending on

> the assigned task and available components. As the current state of the art in autonomous self-assembly, swarm-bots offer insight into the potential versatility and robustness that robots may possess to perform missions beyond human abilities.[485]

In 2030 I think each family in the developed world will have many inexpensive robots around the home and in their vehicles. Robots are going to become our companions, our watchdogs and our health monitors. They will provide companionship for the lonely and, at last, we all will have 'someone to talk to.'

Perhaps the last word on robots should be given to Professor Marvin Minsky[486] of M.I.T. who is regarded by many (including me) as the father of artificial intelligence. In 1994 he wrote (paraphrasing Alan Turing):

> Will robots inherit the Earth? Yes, but they will be our children. [487]

Part Five

Human Health And Longevity

Do you want to live for ever? When you are older would you like to receive rejuvenation therapy to ensure that your skin, hair and internal organs regenerate themselves (and then continue to regenerate themselves repeatedly) so they never reach a biological age greater than thirty or forty? Would you like to have your personal DNA decoded so that any predispositions to disease or malady can be treated *before* such conditions occur?

All of the seemingly preposterous propositions in the paragraph above will have become possible, or will be about to become possible, by the time we reach 2030. The reason is that accelerating, exponential technological

developments applies to the field of medicine as it does to all other scientific disciplines.

Already, personal genomes are being analysed which will provide enormous help for doctors seeking the best way to treat an individual's disease (or prevent it). The New York Times reported in 2007 that the first human to be handed a copy of his personal genetic code was a very appropriate recipient:

> James D. Watson, who helped crack the DNA code half a century ago, last week became the first person handed the full text of his own DNA on a small computer disk. But he won't be the last.
>
> Soon enough, scientists say, we will all be able to decipher our own genomes - the six billion letters of genetic code containing the complete inventory of the traits we inherited from our parents - for as little as $1,000.[488]

I had my own genome – or, at least the parts of it currently useful for medical purposes – analysed in 2009 by the Californian company 23andMe[489]. I will admit to feeling some trepidation as I waited for the analysis, but at least I was old enough to know that any prediction that I would die young could be ruled out.

When I was informed that my results were available on a secure web site I was fascinated to learn that what my susceptibilities are and where I have some genetic strengths.

I have learned, for instance, that if I were to have a heart problem, beta blocker medication is likely to be ineffective for my gene type. I also learned that I have a higher chance of contracting Type II diabetes than

average people and that I'm slightly more likely to suffer from Celiac Disease (gluten intolerance).

In 2011 the company 23andMe added a new test; they asked me if I would like to know whether I possessed one or more of the marker DNA sets (SNPs) that suggest a predisposition to Alzheimer's Disease.

Single nucleotide polymorphisms, or SNPs (pronounced "snips") are DNA sequence variations that occur when a single nucleotide (A,T,C,or G) in the genome sequence is altered. One of the genes associated with Alzheimer's disease, apolipoprotein E or *ApoE*, is a good example of how SNPs affect disease development. *ApoE* contains two SNPs that result in three possible alleles for this gene: E2, E3, and E4. Each allele differs by one DNA base, and the protein product of each gene differs by one amino acid. These are markers that are common to many Alzheimer's sufferers, and they also run in families.

About 30 per cent of the world's population carries one of these markers that suggests a predisposition to Alzheimer's. But having this SNP marker does not mean that the carrier will definitely contract the disease. Equally, a person who does not carry the marker may contract Alzheimer's Disease. It's just that those who carry this marker have a higher likelihood of contracting the distressing disease. But a small percentage of humans carry two of these SNP markers and a very small percentage are unlucky enough to carry three of the markers. In these cases the likelihood of the carrier suffering from Alzheimer's disease later in life is high or very high.

Famously, Nobel Prize-Winner James Watson, one of the two scientists who discovered DNA in 1953, was the first man to have his genome decoded in 2007. The decoders asked Professor Watson if he would like to know whether or not he carried any of the genetic markers that indicate a predisposition to Alzheimer's Disease. He said he would prefer not to know[490].

But I felt differently. I was an adopted child and I therefore have no information about my biological parents so, unlike most people, I am unable to look to parents, grandparents or uncles and aunts to see if dementia (as Alzheimer's used to be called) has a presence in my family.

Therefore, when 23and Me offered me a test that could predict my genetic predisposition to Alzheimer's Disease the temptation to ask for the test was even greater than my fear of finding a bad result. And I had my daughter to consider. Although she has a family medical history on her mother's side, she has none from mine.

You will be able to imagine how my heart was beating when the results came through and I was about to click on the 'OK' button to see whether or not I was especially susceptible to this awful disease. 23andMe advised me to seek medical counseling first and presented various legal hurdles for me to overcome before I saw the results. But then I read the news: thankfully, I have none of the marker sequences that suggest the likelihood that I will get Alzheimer's. This does not mean that I will not suffer from the disease, but it does mean that I am not genetically predisposed towards it.

I amused and intrigued my family doctor when I told him about the DNA analysis, and he couldn't resist asking me for access and taking a peek at the results. He said he wished he had the data for all of his patients (and he added that most physicians are not yet geared up to tailor medical treatment to individual genomes).

It is also true that some of the hopes raised around the time that the human genome was first sequenced (2001) of new 'super drugs' tailored to personal genetics have not yet materialised. As The Economist warned in 2010 under the headline '[Genomics has not yet delivered the drugs, but it will]**':**

> By now, if you had believed the more bullish pronouncements made at the time the human-genome project was coming to fruition, the pipelines of pharmaceutical companies would have been bursting with aspiring treatments for everything from Alzheimer's disease to Zollinger-Ellison syndrome, as the genes involved in these illnesses were identified and drug molecules that could correct malfunctions of those genes were discovered. In fact, the pipelines are empty; company analysts often seem to regard research as a drain on the balance-sheet, rather than an asset; and drug companies seem to be reinventing themselves as marketing firms for established products. The explanation is a toxic mix of science and economics, but the result is an industry ripe for disruption[491].

As a result of multiple advances in medical science, some futurists are convinced that if they can live long enough to reach 2030 or 2040 medical science will have advanced sufficiently to enable them to both rejuvenate their aged carcases and then to go on living in a constantly rejuvenated form for an indefinite period.

The American futurist Ray Kurzweil is probably the best-known exponent of this idea. With his medical collaborator Dr Terry Grossman,[492] Kurzweil wrote a book in 2004 called 'Fantastic Voyage – Live Long Enough To Live

For Ever'. In what amounts to a manifesto, the authors detail their research into emerging medical technologies which, they believe, will soon enable them to, as they say, 'live for ever'.

> Within a couple of decades we will have the knowledge to revitalize our health, expand our experiences – such as full-immersion virtual reality incorporating all of the senses, augmented reality, and enhanced human intelligence and capability – and expand our horizons.
>
> As we peer even further into the 21st Century, nanotechnology will enable us to rebuild and extend our bodies and brains and create virtually any product from mere information, resulting in remarkable gains in prosperity. We will develop means to expand our physical and mental capabilities vastly by directly interfacing our biological systems with human-created technology…
>
> Another important line of attack is to regrow our cells, tissues, and even whole organs, and introduce them into our bodies without surgery. One major benefit of therapeutic cloning is that we will be able to create these new tissues and organs from versions of our cells that have also been made younger – the emerging field of rejuvenation medicine.[493]

And some years after that book was first published, Ray Kurzweil is now predicting 'immortality medicine' will arrive even sooner than he first suggested. Reporting on a conference called 'Transvision 2007' Reason Magazine reported:

> Kurzweil believes that humanity will accelerate itself to utopia (immortality, ubiquitous AI, nanotech abundance) in the next 20 to 30 years. For example, he noted that average life expectancy increases by about 3 months every year. Kurzweil then claimed that longevity trends are accelerating so fast that the life expectancy will increase more than one year for each year that passes in about 15 years. In other words, if you can hang on another 15 years, your life expectancy could be indefinitely long.[494]

In 2009 The Daily Telegraph reported:

> Scientist Ray Kurzweil claims humans could become immortal in as little as 20 years' time through nanotechnology and an increased understanding of how the body works.

> The 61-year-old American, who has predicted new technologies arriving before, says our understanding of genes and computer technology is accelerating at an incredible rate.
>
> He says theoretically, at the rate our understanding is increasing, nanotechnologies capable of replacing many of our vital organs could be available in 20 years time.
>
> Mr Kurzweil adds that although his claims may seem far-fetched, artificial pancreases and neural implants are already available.
>
> Mr Kurzweil calls his theory the Law of Accelerating Returns. Writing in *The Sun*, Mr Kurzweil said: "I and many other scientists now believe that in around 20 years we will have the means to reprogramme our bodies' stone-age software so we can halt, then reverse, ageing. Then nanotechnology will let us live for ever.
>
> "Ultimately, nanobots will replace blood cells and do their work thousands of times more effectively[495].

And in December 2010 New Scientist reported:

> The ultimate pattern that preoccupies him (Ray Kurzweil) is the human brain. Kurzweil believes the exponential growth of artificial intelligence, biotechnology and nanotechnology means that before 2050 the full intricacy of his brain - and, he hopes, his consciousness and identity - can be copied and uploaded into a non-biological substrate. His goal - obsession, if you will - is to surf the accelerating high-tech tsunami long enough to transcend biology and achieve the dream of immortality.
>
> All this flows from Kurzweil's Law of Accelerating Returns, a generalisation of Moore's Law, which predicts ongoing exponential growth of key technologies. What this means, Kurzweil writes, is that "...we won't experience 100 years of progress in the 21st century - it will be more like 20,000 years of progress (at today's rate)".
>
> If he's right, before 2050 all information-based technologies will be millions of times more advanced and AI will far outshine the power of all human brains combined - development so explosive it is best described as The Singularity, a term he borrowed from other futurists but made his own[496].

Before considering the possibilities of being able to live forever if we can only make it to the year circa 2024, it is worth asking a moral question about the ambition for extreme longevity.

This is what British philosopher Roger Scruton had to say in 2010 on the prospects raised by Ray Kurzeil and others:

> In the world that we are now entering there is a striking new source of false hope, in the "trans-humanism" of people like Ray Kurzweil, Max More and their followers. The transhumanists believe that we will replace ourselves with immortal cyborgs, who will emerge from the discarded shell of humanity like the blessed souls from the grave in some medieval Last Judgement.
>
> The transhumanists don't worry about Huxley's Brave New World: they don't believe that the old-fashioned virtues and emotions lamented by Huxley have much of a future in any case. The important thing, they tell us, is the promise of increasing power, increasing scope, increasing ability to vanquish the long-term enemies of mankind, such as disease, ageing, incapacity and death.
>
> But to whom are they addressing their argument? If it is addressed to you and me, why should we consider it? Why should we be working for a future in which creatures like us won't exist, and in which human happiness as we know it will no longer be obtainable?[497]

I began this book with the observation that the world's greatest problem is the massively increased population the planet will have to carry later in the century – probably a total of between nine and twelve billion by 2050 – and the idea of wealthy, successful individuals in the rich world (not Ray Kurzweil or Dr Grossman specifically) who are now plotting to extend their lives indefinitely seems, at first glance, somewhat selfish. But individual human rights dictate that we are all free to strive for both our health and for the maximum lifespan (if we are able to afford to do so) and it will certainly be true that the pioneers in the field of human longevity will show the rest of

us what's possible. It will be those demonstrations (if successful) that will inspire others to follow their lead.

Ray Kurzweil is now 64 years old and he claims that by taking what he calls 'aggressive supplementation' and living a particular and quite rigorous lifestyle he was able to cure himself of diabetes without medication. He also claims that his medically-checked biological age to be closer to 40, rather than to 64 years old.

Kurzweil takes 250 supplements a day[498] (vitamins, anti-toxicants and other substances, some intravenously, that are believed to promote health and fight off ageing) and he receives two blood transfusions a week – all in an attempt to remain as youthful as possible. Is he yet another American crackpot on a personal quest for immortality or a well-informed, scientifically-educated futurist who has glimpsed that if he can just remain healthy for another fifteen years he may arrive at a point at which science can offer him age reversal and a greatly extended youthful life?

Kurzweil and his writing partner Dr Grossman are not alone in believing that human longevity is soon going to be significantly extended. James Canton is another noted American futurist who sees dramatic possibilities being offered by medicine of the future. Writing in his book 'The Extreme Future' he predicts:

> Longevity scientists that I have met are unlocking the secrets of age embedded in our genes, and as organ replacement and stem-cell research frontiers are being crossed, I forecast that the era of longer living, beyond one hundred years of age, will become common with ten years and be considered a birthright by 2025, due to Longevity Medicine. [499]

These projections sound almost too fantastic to be true but, after weighing the science and reviewing all available evidence, I too have come to the conclusion that both rejuvenation therapies and life extension will become possible for humans in the 21st Century. But I am not convinced by the time-scale suggested by Mssrs. Kurzweil, Grossman and Canton, nor by the simplistic dream of wanting to 'live forever'.

Futurologists study trends and it is clear that human longevity has steadily, but quite significantly, begun to increase without the help of specific rejuvenation treatments. In a paper entitled 'Emergence of Super Centenarians in Low Mortality Countries,' Dr Jean-Marie Robine of INSERM, France and Professor James W. Vaupel of the Max Planck Institute, Germany, write:

> Although the exponential increase in the number of centenarians which started just after World War II is today well documented in Europe and Japan, this is still not the case for extremely old persons having reached the age of 105 years – the semi super centenarians – or even of 110 years – the super centenarians.
>
> The first cases of validated super centenarians appeared in the 1960s but their numbers have steadily increased since the mid 1980s, The current prevalence of known super-centenarians in low mortality countries involved in the International Database on Longevity (IDL) is approximately 10 times more than in the mid 1970s.
>
> In roughly twenty years, from 1980 to 2000, the maximum reported age at death, assumed to indicate the maximum life span of the human species and itself seen as a quite stable characteristic of our species, has increased by about 10 years from 112 to 122 years.[500]

By 2030 I think a few humans will be pushing maximum life boundaries to 130 years and beyond. It is almost certain that both genuine and effective rejuvenation and life extension therapies will be available and in widespread

use, although I doubt that indefinite life extension will be achievable at that point.

The biggest question I have about the notion of 'living forever' is whether human beings are psychologically prepared for very extended life spans. This question is something that has never been contemplated before in the whole of human evolution. We have never previously had to consider the likely attitude of a 100 year-old mind (or, more accurately, a biologically youthful mind with 100 years of experience) inhabiting the body of a 30 year-old. Will the mind be as young, as energetic and as lustful for life as the body? Or is there an upper psychological limit to human experience, a point of world weariness at which the psyche itself become exhausted? We don't know, but by 2030 we will be well on our way to finding out.

Technology, Patient Power And The Medical Profession

Until very recently, 'health care' meant 'sickness care'. When patients became ill doctors tried to find a cure or a treatment for their malady. But this began to change in the mid-1990s when the healthcare profession began to recognise that preventive treatments for diseases and conditions that threatened to emerge were more efficient (and more economical) than treating those conditions *after* they had manifested themselves. Perhaps the best example of such preventive medical practice is the widespread use of 'Lipitor', [501] the world's most widely prescribed cholesterol-lowering drug. Raised cholesterol is an important indicator of potential cardio-vascular

problems and Lipitor and similar drugs reduce the build up of cholesterol and thus reduce the likelihood of cardio-vascular disease developing.

Over the next twenty years technology itself and technology-driven developments in medical science will push medicine more and more towards the preventive model. The role of the patient and the role of the healthcare professional will also change, as technology causes more power to be transferred to the patient.

Even today the internet has given the inquiring patient instant access to a large body of medical information previously available only to doctors. While making the important caveat that information on the internet is not to be trusted automatically, and with the important observation that the proper interpretation of medical information may be impossible without medical training, it is now clear that the internet is empowering non-medics to the point that many doctors are intimidated by patients who arrive in their surgeries with internet print-outs under their arm (let alone their own DNA analysis).

With common sense and caution it is now possible for a patient to review the world's literature about specific drugs or treatments, it is possible to instantly link up with others who suffer, for example, from breast cancer, sarcoidosis or tennis elbow. Specific treatments (and specific doctors and specific hospitals) can be discussed and compared with thousands of fellow patients both locally and all around the world. It is no longer possible for a doctor to assume that he or she has exclusive access to medical knowledge and to the experiences of others suffering a common ailment. The inquiring

patient has suddenly and comprehensively been empowered (and has been given important new sources of support).

My own general practitioner – the one fascinated by my genome decoding – is particularly internet-savvy and he is unashamed to Google for medical information while I am sitting in his office, even going so far as to guide me to web sites which offer the most trustworthy medical information. He and I have formed a partnership; I do my best to remain healthy, he does his best to support me. Medicine is changing rapidly and, despite prevailing medical attitudes that wish to 'pathologize' every condition (identify a category or syndrome to which a condition can belong before delivering treatment), new technology, new drugs, new diagnostic tools and new therapies will turn medicine into a science focussed on 'prevent and extend'.

Monitoring Our Health

As inexpensive technology makes it possible for us to take more responsibility for maintaining our own health we will start to monitor our body's real-time performance, even when we are not ill. Such monitoring will include self-administered regular checks of blood pressure, blood-glucose level and cholesterol level. Today such home checks are carried out using off-the-shelf test kits and blood-pressure machines. Soon we will be wearing technology that monitors our health for us and which communicates via the 'super-web' to store medical data in case any retrospective analysis is needed in the future. In the slightly longer term technology worn on our bodies will automatically call for assistance and will even administer

emergency treatments if we suffer a heart attack, stroke or other serious and life-threatening ailment. These are not new ideas.

In 1986 I set up a company in the UK to design, develop and manufacture wrist watches which would also act as health monitors (a business intended to be a complimentary sideline to my writing and futurology). I imagined stylish timepieces that could check the wearer's blood pressure, test the levels of glucose and insulin in the body (from perspiration analysis) and which would eventually be developed to carry small doses of adrenaline, insulin and other chemicals and drugs which, if administered early enough, can save a life. I imagined a time when wearing such a watch would not only be a cultural and fashion norm, but would be a requirement laid down by medical insurers.

Of course, there is yawning gap between imagination and practicality and I eventually came to the reluctant conclusion that the electronics and physiological testing systems of 1986 could not be integrated and scaled down into a single device small enough to be worn anywhere on the body. After some months of expensive research I reluctantly put the idea aside.

Now, over twenty-five years later, wrist blood pressure monitors exist[502] and these models have been successfully tested for accuracy by the medical authorities. These devices still look like medical equipment, however, but as we all start to take more responsibility for maintaining our own health, we can expect to see more multiple-function wrist devices being developed which are also stylish and fashion-conscious.

And others are also working to make these health-monitoring ideas a reality. As Ray Kurzweil and Dr Terry Grossman announced in 'Fantastic Voyage':

> Within several years, we will have the means of continually monitoring the status of our bodies to fine-tune our health programmes as well as provide early warning of emergencies such as heart attacks. The authors are working on this type of system with biomedical company United Therapeutics,[503] using miniaturized sensors, computers, and wireless communication. Researchers at Edinburgh University are developing spray-on nancomputers for health monitoring. Their goal: a device the size of a grain of sand that combines a computer, a wireless communication system, and sensors for heat, pressure, light, magnetic fields, and electric currents. [504]

And as we connect ourselves and the most intimate parts of our physiology to the always-on, always-connected 'super web' telemedicine[505] will begin to play a much large role in our healthcare. 'Telemedicine' means 'medical services delivered from afar' and although there will be many instances in which an in-person physical examination will remain vital, many routine interactions between patients and care providers will be provided across the networks. Telemedicine will become more and more effective as our bodies become more 'wired' and as more physical information about our bodies' performance is uploaded for expert analysis. Telesurgery, particularly in partnership with robotics, is already a reality with the first trans-Atlantic teleoperation being carried out in 2001 as the BBC reported:

> The first major trans-Atlantic telesurgical operation has been carried out. Doctors in the United States removed a gall bladder from a patient in eastern France by remotely operating a surgical robot arm.
>
> The procedure could make it possible for a surgeon to perform an operation on a patient anywhere in the world.[506]

By 2030, humans will be receiving a significant part of their healthcare via telemedicine and the networks (with adequate security over private data) will provide storage or your personal medical data and records which you, or a medical professional who has your approval, can access at any time from anywhere in the world.

Paying For Our Healthcare

But before I get ahead of myself in this survey of medical wonders yet to come, it is necessary to understand that we face an extremely difficult future for health-care services in the developed world. I promised earlier that I would not commit the solecism of taking a Panglossian view of the future and for that reason it is necessary to point out that the 'Baby Boomer' generation in North America, Europe, and some parts of Asia has started to retire and, inevitably, will eventually fall victim to the maladies of old age (relatively few will have early access to rejuvenation treatments). This is the largest group of people in the population demographic and they are going to start making heavy demands on health services just as their generation is becoming economically unproductive (and therefore able to contribute less in taxes to fund the health services). How good or bad healthcare services will be in caring for these millions of **old** people depends on political decisions and national cultures as much as a nation's economic performance. As is revealed below, future energy security is not the only sector in which the United States has got itself into a mess.

In his 2007 book, 'Future, Inc,' Washington D.C.-based futurist Eric Garland[507] wrote of the American health-care system:

> The most important thing driving the future of health care is something you probably do not need to be told – it is phenomenally costly. The United States, just one example, spends approximately $1.9 trillion on its health care system. That figure is larger than the entire economy of nearly every country on Earth. The cost of health care is rising an average of 8 per cent annually, outpacing growth in wages every year for the last five. Moreover, as the Baby Boomers begin to age that number is expected to double. America alone could be spending $4 trillion a year on health care. Given that the United States devotes 18 cents of every dollar to health care, the idea of doubling that number is daunting, especially because recent studies show we don't seem to be any healthier than those in other developed countries, like the UK, which spends considerably less.[508]

Since then, of course, Barack Obama has managed to get a health care reform bill onto U.S. statute books but, at the time of writing it is far from clear whether his bitter opponents will allow the new bill to take effect. Major challenges still lay head for the reform.

Although scientific breakthroughs and new, more effective treatments and forms of preventive medicine are wonderful, such developments also push up the cost of health care – and at an alarming rate. Just at the time when millions of newly elderly people will be placing demands on the developed world's health services, new technologies, treatments and drugs will be offering new and sometimes very expensive, forms of treatment.

Every nation has its own solution to public healthcare provision and some countries do it very much better than others. And while it is true that the new wealth generated from the accelerating, exponential development of general technologies will be considerable, it is clear to me that for the poor and less well-off in our societies medical rationing will be the norm in many

countries (as it is today). Some of the more advanced technological treatments will only be available to those who are able to pay for them, over and above any contributions they may have already made to fund their healthcare services. In most countries, the wealthy will be the healthy.

Beautiful, Clever You

But in our increasingly rich developed world there will be plenty of people able to pay for health care and health treatments and there will be more than enough of them to ensure that research into new drugs and new forms of treatments will not suddenly dry up as state-provided health services crumble under the weight of the baby boomers' retirement maladies.

By 2030 private medicine will be offering the much-enlarged wealthy classes opportunities to change themselves in some very dramatic ways. This trend is already well developed as rich people pay for cosmetic surgery to enhance or rejuvenate their looks and replace their age-discoloured teeth with dazzling Hollywood smiles. Soon grey hair may even be restored to its natural colour without the use of dyes, or you may even be able to alter the colour of your hair from inside your hair follicles. As New Scientist reported in 2007:

> The particular gene variants that make our hair black, brown or blonde remain elusive, but we do at least have a better handle on a most vexing aspect of hair colour - its tendency to go away. David Fisher's team at Harvard Medical School has recently shown that melanocyte stem cells near the top of the hair follicle disappear just before a hair turns white. This means the mature melanocytes at the base of the follicle are not

> replaced when the hair falls out and a new one begins to form (*Science*, vol 307, p 720).
>
> Greyness could be reversible. In fact, an existing cancer drug seems to occasionally restore pigmentation, and more reliable, safer methods are on the horizon. For instance, AntiCancer of San Diego, California, has developed ways of delivering drugs or genes to hair follicles in fatty sacs. The payload could include genes that restore melanin production, says company president Robert Hoffman. The problem is getting high enough gene expression in all the cells, he says, to avoid producing streaky, partially pigmented hair.[509]

And male baldness, a most troubling debilitation for many men, may soon be nothing but a bad memory. So far this has been a condition that has refused to yield to medical science. Hair transplants have been regularly carried out since the 1970s but few patients have sufficient donor follicles to make the treatment really effective. Now, however, it finally seems that a permanent cure may be on the way (and will almost certainly be widely available by 2030). As I reported in the March 2011 edition of my newsletter Glimpses Of The Future:

> **Male Baldness Cured! (Again)**
> I seem to have been writing about promising new treatments for male baldness for over 30 years but, judging from the appearance of many of my friends, these cures have failed to arrive (at least in the mainstream marketplace).
>
> Now researchers from UCLA and the Veterans Administration in the U.S.A. may have inadvertently stumbled across a new treatment for hair loss. During an investigation into the affect of stress on gastrointestinal function, the researchers believe they may have found a chemical compound that induces hair growth by blocking a stress-related hormone associated with hair loss. (It was a similarly serendipitous discovery in the labs that led to the development of Viagra.)
> At present new hair growth has only been induced in mice, but research into possible human treatments is now underway.
> (Those old guys with a full head of hair and a pocketful of Viagra are going to be insufferable!)[510]

But it won't be only treatments for troubling but minor conditions that will be available in 2030. By that point medicine will be able to offer patients specific 'enhancements' to their physiology. At this point it is important to put the notion of 'human enhancement' into social context. In his 2006 paper 'Cognitive Enhancement: Methods, Ethics, Regulatory Challenges,' Dr Nick Bostrom provides some perspective:

> Most efforts to enhance cognition are of a rather mundane nature, and some have been practiced for thousands of years. The prime example is education and training, where the goal is often not only to impart specific skills or information, but also to improve general mental faculties such as concentration, memory, and critical thinking. Other forms of mental training, such as yoga, martial arts, meditation, and creativity courses are also in common use. Caffeine is widely used to improve alertness. Herbal extracts reputed to improve memory are popular, with sales of *Ginko biloba* alone in the order of several hundred million dollars annually in the US3 In an ordinary supermarket we find a staggering number of energy drinks on display, vying for consumers hoping to turbo-charge their brains.[511]

But by 2030 wealthy people will be expecting far more than just cosmetic improvements from their doctors and the enhancements available from education and fizzy drinks. The genetic manipulation of proteins and molecules, sometimes referred to as 'genetic engineering' or 'germline engineering', holds some extreme promises for the treatment of disease and even the enhancement, physically and intellectually, of individual humans.

Writing in his book 'Mind Set! Reset Your Thinking And See The Future', the Vienna-based futurist John Naisbitt describes some of the hopes for germline engineering and warns of its implications:

> The great dilemma of the twenty-first century will be that although germline engineering will allow us to treat and eventually eliminate diseases and disorders such as Alzheimer's, Downs syndrome, and Parkinson's, the very same technology will allow us to make people

> taller, stronger, smarter, more beautiful. In short, we will be able to create a perfect race. This of course falls under the long shadow of eugenics, the perfection of the human race. Hitler had the idea, but he did not have the science. Here comes the science.
>
> Once the first step is made, we will be on a path of no return. Dispute over this matter will lead to a huge confrontation between science and religion, between feasibility and humanity. It is a confrontation shaking up basic beliefs and values as during the times of Galileo and Darwin.[512]

And his fellow American futurist Jeremy Rifkin also warns of the implications of genetic engineering is his book, 'The Hydrogen Economy':

> Physics and chemistry, which have dominated the era just passing, influencing every aspect of our existence, including the smallest particulars of our way of life, are making room for the age of biology. The mapping and manipulation of human, animal and plant genomes open the door to a new era in which life itself becomes the ultimate manipulable commodity. The biotech era is beginning to raise fundamental questions about the nature of human nature, and the public is quickly being swept up in a great debate between those who view the new age as a biological renaissance and others who warn of the coming of a commercial eugenics civilization.[513]

The key question is, will the rich people of 2030 consider using genetic engineering when planning to have a child? And I don't just mean young wealthy people – I also mean older wealthy people. Rejuvenation techniques will make the 70 year-olds of 2030 look like 30 year-olds and, with a much extended life expectancy. And with medical advances already allowing mothers to give birth in their sixties,[514] how many older couples will start to plan new families?

At first prospective parents will have their embryos screened to weed out any which carry genes predictive of future disease and they will almost certainly select the sex of their unborn child in this way. The ethicist and

philosopher Nick Bostrom considered this matter in his 2006 paper 'Cognitive Enhancement: Methods, Ethics, Regulatory Challenges,':

> Some enhancements do not increase the capacity of any existing being but rather cause a new person to come into existence with greater capacities than some other possible person would have had who could have come into existence instead. This is what happens in embryo selection. At present, preimplantation genetic diagnosis is used mainly to select out embryos with genetic disease, and occasionally for the purpose of sex selection. In the future, however, it might become possible to test for a variety of genes known to correlate with desirable attributes, including cognitive capacity. Genetic engineering might also be used to remove or insert genes into a zygote or an early embryo. In some cases, it might be unclear whether the outcome is a new individual or the same individual with a genetic modification.[515]

The problem comes when medicine starts to offer the possibility of genetic manipulation to make the prospective child grow taller, be more handsome or beautiful, more musically gifted or have a greater intellect. This is not yet possible today, but by 2030 it almost certainly will be and whether or not such 'treatment' is being offered in the developed world will depend upon each nation's legislation and regulation of the science.

It is tempting to believe that today's widespread natural repugnance at the concept of 'designer babies' will still be the cultural norm in twenty years time. But futurologists learn that public opinion can sometimes change quickly, dramatically and in unexpected ways. For example, I recall describing what we now know as 'the surveillance society' to a British audience in the early 1980s. There was uproar and, almost to a person, the audience members were appalled at such a 'Big Brother' idea and all were certain that such a thing would never be tolerated in the UK. Today, although there many vociferous critics of our mushrooming surveillance

infrastructure, the vast majority of people in Britain are entirely content to be watched over. It is not even an issue for any of the major political parties.

So it could be with genetic engineering and human enhancements. At first the science will show the huge benefits in eradicating disease and preventing it occurring. The advantages offered will be clear and the procedure simple. For example, as The Times reported in 2007:

> A pill that can correct a wide range of faulty genes which cause crippling illnesses should be available within three years, promising a revolution in the treatment of thousands of conditions.
>
> The drug, known as PTC124, has already had encouraging results in patients with Duchenne muscular dystrophy and cystic fibrosis. The final phase of clinical trials is to begin this year, and it could be licensed as early as 2009.[516]

And by 2011 the drug had been given the name 'Ataluren' and clinical trials are progressing:

> Ataluren, formerly known as PTC124, is a novel small-molecular agent designed to make ribosomes become less sensitive to, or possibly ignore premature stop codons. This may be particularly beneficial in genetic disorders where the mRNA contains a mutation causing premature stop codon or nonsense codon. However, it is not equally effective with every stop codon, working best on the sequence 'UGA'.
>
> PTC124 has been tested on healthy humans and humans carrying genetic disorders caused by nonsense mutations, such as some people with cystic fibrosis and Duchenne muscular dystrophy. Clinical trials are proceeding for several genetic disorders, in the subset of affected people who have nonsense mutations (typically <10% of those with the disorder).

As such gene-based and gene-focused treatments become accepted across society doctors, parents and scientists may begin introducing improvements to the germline that society perceives as beneficial – for example one study

has shown that the increase in income from only a single additional IQ point to be 2.1 per cent for men and 3.6 per cent for women![517] So even relatively small increases in mental performance will have a huge impact on how well a child will do in life, and if a nation state were to consider the economic impact of a collective rise in national IQs… well, thankfully, that's something only the most extreme totalitarian state would contemplate.

More mundanely these 'enhancements' could also include screening embryos against colour blindness, tone deafness and other 'defects' not normally considered diseases. From there it is a small step to making human enhancements.

Imagine two successful painters – visual artists – planning to have their first child, a girl. 'Shall we improve her colour vision, darling?' would be a very hard suggestion to turn down. And, as research published in 2007 suggests, 'an almost instantaneous upgrade' to human perception of colour may become available:

> Although mice, like most mammals, typically view the world with a limited color palette – similar to what some people with red-green color blindness see – scientists have now transformed their vision by introducing a single human gene into a mouse chromosome. The human gene codes for a light sensor that mice do not normally possess, and its insertion allowed the mice to distinguish colors as never before.[518]

Because genetic manipulation of the embryo affects the rights of unborn children, legislation and regulation will ensure these rights are protected. It is impossible to know what these laws will mandate in 2030 but, whether or not genetic enhancement of embryos is banned in a given country, some prospective parents will use other, less strict, jurisdictions to design babies to their liking. It is human nature.

Nick Bostrom explains how a future society might regard the whole issue of human enhancement:

> For example, in addition to the gap between the rich and the poor, there is also a gap between the cognitively gifted and the cognitively deficient. One scenario might be that the wealth gap increases at the same time as the talent gap decreases because it is generally easier to enhance individuals at the low end of the performance spectrum than those at the high end (whose brains are already functioning close to their biological optimum). This could add a degree of complexity that is often overlooked in the ethical literature on inequality. One should also have to consider under what conditions society might have an obligation to ensure universal access to interventions that improve cognitive performance. An analogy might be drawn to public libraries and basic education.[519]

Rejuvenation And Longevity

If the unborn children of 2030 will be protected from genetic enhancement by law, there will be nothing to stop consenting adults seeking to medically enhance or rejuvenate themselves.

By 2030 stem cell medicine[520] will be mature and widely practised. A 'stem cell' is an early stage human cell which retains the ability to grow into any type of human cell – a heart cell, a brain cell, a skin cell, etc. These properties are now being exploited to grow replacement parts and organs for humans.

In 'Extreme Future' James Canton listed some of the benefits expected from stem cell medicine by 2030 .

- New organs, including hearts and lungs
- New bone growth for legs, arms and backs
- New sensory functions and optic nerves to restore eyesight
- New cancer treatments
- New nerves to heal muscles and to restore movement
- New cells to offset the aging brain[521]

Significant progress in stem cell medicine is already being made and development is increasingly rapid. As MIT Technology Review reported in 2007:

> An efficient new method to generate what appears to be a novel type of stem cell could be a boon to diseases linked to lack of blood flow. Scientists in Massachusetts and Florida have developed a way to coax embryonic stem cells into a more adult form of stem cell that has the potential to form blood vessels. The new type of cells helped repair tissue in animals that had had heart attacks or eye damage due to diabetes.[522]

And one of the insights that is now emerging is that some cancer cells may be thought of as stem cells that are developing out of control As Wired reported in 2008:

> A radical new cancer treatment is about to emerge from a scientific breakthrough in the understanding of how tumors grow.
>
> The theory is that a fraction of tumor cells, dubbed cancer stem cells, is responsible for the malignancy of tumors. While controversial, the theory is gaining adherents among once-skeptical oncologists and investors. It posits that a small fraction of cancerous cells are responsible for stimulating the growth of tumors. In the way other stem cells create organs, these cells create tumors.
>
> In two signs of the theory's perceived potential, the *Journal of Clinical Oncology* published a special 18-article supplement last week on research in the field, just as the leading cancer stem cell treatment startup, Oncomed, finishes readying its first drug candidate for human trials[523].

It is the potential of stem cell medicine (coupled with the potential of molecular nanotechnology) that turns some otherwise quite level-headed futurists into the modern equivalent of ancient Egyptian Pharaohs lusting for immortality. For example, the developing ability to practise medicine at the nano-scale[524] coupled with stem cell technology holds out amazing promise. As The Project on Emerging Nanotechnologies (a partnership between the Woodrow Wilson International Center for Scholars and the Pew Charitable Trusts) suggests on its website:

> Imagine a world where damaged organs in your body - kidneys, liver, heart - can be stimulated to heal themselves. Envision people tragically paralyzed whose injured spinal cords can be repaired. Think about individuals suffering from the debilitating effects of Parkinson's or Alzheimer's relieved of their symptoms – completely and permanently.
>
> In a dramatic demonstration of what nanotechnology might achieve in regenerative medicine, paralyzed lab mice with spinal cord injuries have regained the ability to walk using their hind limbs six weeks after a simple injection of a purpose-designed nanomaterial.[525]

Nanomedicine and stem cell treatments hold out huge hope for the disabled as well as for those less needy individuals who seek to extend their natural life spans. It is to be hoped that the money being spent by those who wish to rejuvenate themselves and 'live forever' drive forwards the research that develops cures for the paralysed and those suffering from what in 2007 are still intractable diseases.

Man's Transhuman Future

As I suggested in the previous section, 'Daily Life in 2030', within twenty years humans will be connecting themselves directly to the 'super-web' via

neural interfaces, body-mounted nano-scale computers and monitoring systems. Many of us will have virtual assistants – software personalities – who are our constant companions and helpmates.

But even as we take technology onto and into our bodies we will have begun to alter our own biology using genetic engineering, stem cell research and nanomedicine – changing what it means to be human. 'Transhuman' and 'transhumanism' are the terms that have already been proposed to describe the new type of augmented and enhanced human that will begin to emerge well before the year 2030. Wikipedia explains the concept as follows:

> Transhumanism (sometimes abbreviated >H or H+) is an international intellectual and cultural movement supporting the use of new sciences and technologies to enhance human mental and physical abilities and aptitudes, and ameliorate what it regards as undesirable and unnecessary aspects of the human condition, such as stupidity, suffering, disease, ageing and involuntary death.[526]

Of course, these increasingly enhanced and augmented transhumans will be occupying a planet on which super-intelligent machines will recently have emerged. The two new forms of entity are almost certain to get together and some futurists are already talking about sexual and romantic attachments between humans and computer personalities.

Whatever the relationships between augmented humans and their robot companions, it is clear that much longer life spans are almost certain for us and, particularly, for our children. In his 1993 paper 'The Coming Technological Singularity: How to Survive in the Post-Human Era' Vernor Vinge makes the following observation about extreme-longevity:

> A mind that stays at the same capacity cannot live forever; after a few thousand years it would look more like a repeating tape loop than a person. To live indefinitely long, the mind itself must grow ... and when it becomes great enough, and looks back ... what fellow-feeling can it have with the soul that it was originally? Certainly the later being would be everything the original was, but so much vastly more.[527]

But before peering into the longer-distance future it is worth taking a reality check about the likely nature of life in 2030. The vast majority of people in the world at that time will still be struggling to make a living and feed their families. Technology development and globalization (if that globalization has been ethically and sustainably pursued) will have lifted additional billions of people out of abject poverty, but for most humans on the planet life will be conducted much as it is today, albeit it with far better communications and improved healthcare.

Beyond the Technological Singularity (which, by my best guess, is likely to occur at some point between 2035 and 2050), however, life will be very different for wealthy people in the developed nations. It is virtually impossible to predict what might be possible once we have computers that are substantially more clever than human beings (and once they start demanding rights for themselves).

In his 2007 book 'Beyond AI: Creating the Conscience of the Machine', Dr Storrs Hall makes an attempt at predicting some of the capabilities such an artificial intelligence (AI) would have (an 'epihuman' is a machine with a capability just above human level, a 'hyperhuman' is an artificial intelligence significantly smarter than human level):

> Imagine an AI that is a thousand epihuman AIs, all tightly integrated together. Such an intellect would be capable of substantially outstripping the human scientific community at any given task and of

> comprehending the entirety of scientific knowledge as a unified whole. A hyperhuman AI would soon begin to improve itself significantly faster than humans could. It could spot the gaps in science and engineering where there was low-hanging fruit and instigate rapid increases in technological capability across the board.
>
> It is as yet poorly understood even in the scientific community just how much headroom remains for improvement with respect to the capabilities of current physical technology. A mature nanotechnology, for example, could replace the entire capital stock—all the factories, buildings, roads, cars, trucks, airplanes, and other machines—of the United States in a week. And that's just using currently understood science, with a dollop of engineering development thrown in.[528]

How might humans react to the arrival of such intelligence, such super-capability on Earth? Quite simply, we don't and can't know.

In the longer term I suspect, as I have for over forty years, that enhanced human beings and super computer intelligence will merge to become a new species that will become our successors, a new non-biological species which will finally be able to spread out and colonize the solar system and, eventually, the universe.

I don't see the super-intelligent computer personalities of the future as being terrifyingly alien beings, but as a natural product and extension of ourselves. They will indeed be our children.

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