THE POLITICS OF GLOBAL WARMING (1): CLIMATE SCIENCE AND SCEPTICISM

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ABSTRACT

Purpose – *The purpose of this chapter is twofold. First, to give a concise account of the current global climate situation, its previous history according to the palaeoclimate record, and climate scientists' predictions of the consequences of various scenarios of global climate change. Then to explain why so many people continue to be oblivious to the enormous risks of continuing with business as usual.*

Methodology/approach – *The approach is through a comprehensive study of the relevant evidence and the scientific and scholarly literature, interwoven with philosophical reflections on their significance.*

Findings – *The findings are as follows: the evidence for the anthropogenic nature of global warming is overwhelming, and the prognoses for continued burning of fossil fuels (sea level rise, extreme weather, etc.) are dire. The denial stems in large part from the undue influence of climate scepticism movements, lavishly funded by the fossil fuel industries, combined with a variety of psycho-social and economic factors.*

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Social implications – *The implications are several. Given the complex nature of global warming, scientists need to do a better job of communicating their findings to the general public, and scholars and academics need to find ways to expose the machinations of the fossil fuel industries. And given the global impact of climate change, citizens of the developed nations need to see that a radical change in their behaviour is demanded not only by considerations of social justice but also even by their own self-interest.*

Originality value – *The value of this philosophical approach is that it affords a more comprehensive view of the situation around global warming than we get from the more specialised disciplines.*

Keywords: Climate change; climate scepticism; climate science; economics; global warming; politics

INTRODUCTION

Globalisation appears to have maddened the world, driven its citizens insane. By burning fossil fuels to provide energy for our high-comfort lifestyles, enjoying unprecedented mobility thanks to automobiles and planes, warmed in winter and cooled in summer, we in the developed world, and many in developing countries too, are driving the planet towards climate tipping points that could plunge civilisation as we know it into catastrophe. As millions in the affected countries lose their homes and livelihoods, there will be domestic chaos and mass migrations. Fortunately, the United States, which has contributed most to the warming and is responsible for blocking meaningful action to mitigate it, has lots of space for climate refugees.[1]

The earth has been under brutal assault for quite some time, suffering insult after insult at the hands of the human race – to the point now where our impact on the planet and its climate threatens to destroy a good portion of the natural resources on which we depend for our very survival. From the perspective of the world's classical philosophies, the wisdom of the ancients in most cultures, the current behaviour of most citizens in the so-called developed world looks like collective insanity, self-destructive madness, massive self-deception resulting in an ignorance so wilful as to be culpable. But those who are inflicting the damage seem incapable of restraining themselves, and the politicians appear not to care about anything beyond their next chance for re-election.

But perhaps they know not what they do. If people knew what is happening on the scale of the planet's climate, as a result of human activity, would they not want to avoid perpetrating a catastrophe that threatens the livelihoods of millions, as well as future generations even of the rich and fortunate? And even if, as many climate scientists now think, we have already altered the atmosphere so much that destructive consequences are unavoidable even if we change our ways immediately, it still makes sense for us to mitigate the ill effects as much as possible. Hope lies in people's coming to face the facts of the situation, to understand the meaning of what we are doing and how we are behaving – and from there to take action to change our collective behaviour.

As the evidence for anthropogenic climate change has accumulated, and scientific theories of how this process works have become increasingly well corroborated, much of the general public – especially in the United States – doubts in its wisdom that human activity is the major cause of the problem.[2] They say that ignorance is bliss, but the strange thing here is that the unrestrained consumption of energy and goods by the developed societies is by no means enhancing our happiness or health. A number of socio-psychological studies have shown that accumulating more money and possessions than we need (and especially in a context of impoverished relations to the earth and the places we inhabit) actually depresses and impairs human flourishing.[3] Higher levels of consumerism appear to correlate better with a rise in consumption of pharmaceuticals than with levels of human fulfilment.

The inability of short-sighted politicians to undertake longer range planning for the sake of the nation contrasts starkly with the attitude of the military, which has an enormous stake in being prepared. While the US government refuses to take action on climate change, the attitude of the Pentagon – hardly a hotbed of tree-hugging dreamers – is aptly realistic. The *Quadrennial Defense Review Report* from 2010 acknowledges the reality of climate change and the enormous challenges it poses. For one thing, the Department of Defense is disconcerted by the amount of military infrastructure at risk because of changing weather patterns: 'In 2008, the National Intelligence Council judged that more than 30 U.S. military installations were already facing elevated levels of risk from rising sea levels' (U.S. Department of Defense, 2010, p. 85). The Pentagon also perceives the more global threats it faces in a warming world, and is preparing for the protection of its military installations abroad.

> Assessments conducted by the intelligence community indicate that climate change could have significant geopolitical impacts around the world, contributing to poverty,

> environmental degradation, and the further weakening of fragile governments. Climate change will contribute to food and water scarcity, will increase the spread of disease, and may spur or exacerbate mass migration. (p. 85)

No need for that qualified 'may' in the last clause: climate refugees, or environmental migrants, are already on the move in the millions, and their numbers are growing. These people are fleeing homes inundated by flooding or destroyed by hurricanes, fields made barren by encroaching salt, crops withering from lack of water. The suffering from displacement from their homes is compounded by violent conflicts over resources. In the words of the *Pentagon Report*:

> While climate change alone does not cause conflict, it may act as an accelerant of instability or conflict, placing a burden to respond on civilian institutions and militaries around the world. In addition, extreme weather events may lead to increased demands for defense support to civil authorities for humanitarian assistance or disaster response both within the United States and overseas. (p. 85)

You bet: a big job ahead. There are always conflicts over resources, and when climate change makes these scarcer, this intensifies the antagonisms. Resource wars are becoming climate wars: convincing scenarios have been projected.[4]

While the politicians in Washington deny and prevaricate, the military at least 'talks the talk':

> The Department is increasing its use of renewable energy supplies and reducing energy demand to improve operational effectiveness, reduce greenhouse gas emissions in support of U.S. climate change initiatives, and protect the Department from energy price fluctuations. The Military Departments have invested in noncarbon power sources such as solar, wind, geothermal, and biomass energy at domestic installations and in vehicles powered by alternative fuels, including hybrid power, electricity, hydrogen, and compressed national gas. (p. 87)

Good work – as long as they are actively reducing their dependence on carbon energy sources. If only U.S. climate change initiatives were more aggressive, the Department of Defense would do even better.

Up to now, those who are hardest hit by the consequences of our abuse of the earth are not the worst abusers among the richer nations but, in a truly tragic irony, those poorer countries who have contributed least to the on-going destruction. And since the attempts of the developing nations to negotiate just and fair political and economic resolutions are constantly being rebuffed (as in the climate summit fiasco in Copenhagen in 2009), we can expect to see an increase in eco-terrorist attacks in the richer nations designed to draw attention to our complicity

in worsening the plight of the poorer. Even if we are spared such terrors, the number of climate refugees will swell to many millions: we shall have been responsible for their parlous condition and will be obliged to take care of them. A climate scientist in Bangladesh has worked out a formula: if you tell him the size of your 'developed-world' carbon footprint, he can tell you how many Bangladeshis will be coming to live with you when their homes are submerged by the sea.[5] It is thus very much in our own self-interest to desist from disrupting the planet's climate – quite apart from the fact that to refrain is likely to make us a good deal happier.

What often seems to conduce to happier lives is the wisdom of indigenous peoples who understand the part of the earth they live on and know how to treat it appropriately. If you know your local climate, you can step outside in the morning and tell from various signs how the day's weather is likely to be. But this kind of understanding is of little direct help in the context of climate change, since the problem is global prior to its local manifestations. We cannot say what is happening to the global climate over the longer term without the aid of natural science, which stretches our understanding based on human lifetimes, using palaeoclimatology to cover ages of the earth that are measured in many millions of years.

CLIMATE SCIENCE

In 2011 the human race broke two world records. First, we discharged an unprecedented amount of carbon dioxide into the atmosphere, mainly by burning fossil fuels: almost *35 billion* tons (Global Carbon Project, 2012). This maximum was matched, not coincidentally, by a further rise in carbon dioxide levels in the atmosphere – to a record level of over 390 parts per million (ppm) (Peters et al., 2011).[6] And now the latest measurements of atmospheric concentrations of CO_2 show the rise continuing to accelerate: the increase during 2012 of 2.67 ppm is the second highest jump ever recorded, the record being 2.93 ppm in 1998 (Vidal, 2013). These trends suggest that we are generating an increase in global average temperatures that is already destroying the livelihoods of many people, and will soon jeopardise the lives of hundreds of millions more.

The connection between carbon dioxide and warming comes as no surprise, since scientists have understood for some time now how the composition of the atmosphere affects temperatures on the earth's surface. In 1824, the French mathematician and physicist Joseph Fourier

likened the atmosphere to a gigantic bell-jar that prevents some of the sun's heat that reflects off the earth from escaping out into space (Fourier, 1824; discussed in Christianson, 1999). Some 30 years later, an Irishman by the name of John Tyndall discovered the processes that are behind this phenomenon, often referred to as 'the natural greenhouse effect'. Tyndall was one of the most versatile scientists of his time, and his interest in the ways various gases absorb and transmit radiation led him to build in 1859 the world's first ratio spectrophotometer.[7] With this device he was able to show that, while the oxygen and nitrogen that make up most of the surrounding air have almost no effect on radiant heat, the water vapour, carbon dioxide and ozone in the atmosphere absorb heat radiation. Heat-trapping gases are distinguished by their selectively absorptive properties, being transparent to the visible, short-wavelength, heat-imparting light of the sun's radiation, but partially blocking the infrared, long-wavelength radiation that's reflected from the surface of the earth.

After a century of burgeoning industrialisation, which produced heat-trapping gases in ever greater quantities, scientists began to realise just how powerful their effects might be. In the late 1950s, an American chemist Charles David Keeling persuaded the US Weather Bureau observatory near the peak of the Mauna Loa volcano on the 'Big Island' of Hawaii to use a technique he had developed for measuring concentrations of CO_2 in the atmosphere. The now famous 'Keeling Curve' shows mean levels of CO_2 to have risen steadily, from 316 ppm in 1959 to over 394 ppm in December 2012.[8]

We can look at these concentrations over a much longer time-frame by analysing air bubbles trapped in ice-cores and at the bottom of the oceans. Drilling at the Vostok ice core in Antarctica can retrieve, at a depth of 3,300 m, bubbles of air from the atmosphere of over 400,000 years ago.[9] The temperature record corroborates the findings from other palaeosciences of a 100,000-year cycle of warming and cooling over the past million years, ice ages alternating with interglacial periods of warmth. These cycles correlate with changes in the earth's orbit, and so the warmings and coolings are an example of natural 'orbital' forcing. They also correlate very closely with changes in levels of carbon dioxide and methane so that the best scientific hypothesis is that the orbital forcing is amplified first by the positive feedback loops from increased concentrations of heat-trapping gases, and then by the 'albedo effect', whereby melting of polar ice reduces the amount of heat reflected back

into the atmosphere. As the authors of 'Climate and Atmospheric History' write in their abstract:

> Atmospheric concentrations of carbon dioxide and methane correlate well with Antarctic air-temperature throughout the record. Present-day atmospheric burdens of these two important greenhouse gases seem to have been unprecedented during the past 420,000 years.

We see considerable variation in levels of carbon dioxide over this long period – but nothing like the jump that kicked in after the Industrial Revolution. And if we look at more recent temperatures on the surface of the earth, as presented by the Goddard Institute of Space Studies at NASA, we see a steady increase since 1880, except for a levelling off between the 1940s and 1970s (Voiland, 2010). The last decade has brought mean temperatures to the highest levels ever recorded.

Let us now consider the steady rise in concentrations of atmospheric CO_2 charted in the Keeling Curve together with the increase in industrial emissions of CO_2 from fossil fuel combustion and cement production over the same period. (Land-use change and deforestation also contribute, but less than 10%.) We know that around half of the CO_2 we put into the atmosphere is absorbed by trees in spring and summer and also by the world's oceans; and if we assume that 57% of fossil-fuel emissions remain airborne, we get a perfect fit between the emissions curve and the CO_2 levels, which suggests that the increasing CO_2 levels is a direct result of human activities.[10] It is this remarkable fit that no climate sceptic has ever seen fit to address, since to dismiss it as mere coincidence would be absurd. And since John Tyndall's discovery of the heat-trapping properties of gases like CO_2 and methane has never been refuted but only corroborated, the obvious conclusion is that recent global warming is to a great extent anthropogenic.

There are, of course, many more factors involved in climate change than those mentioned above: the mechanisms behind climate forcing are complex, and the scientific understanding of climate sensitivity is far from complete. Nevertheless, the vast majority of climate scientists agree that global warming since the Industrial Revolution is being caused by human activities. There are, of course, climate sceptics, who disagree, but they are distinguished more by the shrillness of their rhetoric than the rigor of their science, and very few of them work at the best universities and institutes in climatology. A Stanford University study of the research of 1372 climate scientists showed that 97–98% of the scientists most actively publishing in the field of climate studies 'support the tenets of ACC [anthropogenic

climate change] outlined by the Intergovernmental Panel on Climate Change', and also that 'the relative climate expertise and scientific prominence of the researchers unconvinced of ACC are substantially below that of the convinced researchers' (Anderegg, Prall, Harold, & Schneider, 2010, abstract).[11]

Although natural scientists can be contentious types, they also tend to be conservative and cautious about issuing bold public statements; and on top of that the best climate scientists are usually specialists, and so are reluctant to speak out about the general situation. A salient exception here is James Hansen, who has been Director of the Goddard Institute of Space Studies at NASA (the National Aeronautics and Space Administration) for over 30 years, and is also an adjunct professor in the Department of Earth and Environmental Sciences at Columbia University. Hansen has had a distinguished career in climatology and is a clear articulator of its findings: in 1988 he presented eloquent testimony to the US Congress about climate change, and has since then become more activist, which has led to his being arrested several times in recent years. His book *Storms of My Grandchildren* (2010) provides a clear and coherent overview of the perils of our warming the planet.[12]

Professional organisations of scientists are even more cautious than their individual members, and, in general, the more prestigious the organisation, the more carefully considered the statements it issues. Such professional bodies have an enormous stake in upholding their reputations and so take great pains to avoid saying anything that could possibly make them look stupid. Nevertheless, a recent one-year period saw the appearance of the following pronouncements:

> The G8 + 5 Academies' joint statement: 'Climate change and the transformation of energy technologies for a low carbon future', May 2009 (signed by the National Academies of Sciences of Brazil, Canada, China, France, Germany, India, Italy, Japan, Mexico, Russia, South Africa, the United Kingdom and the United States).
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> President's Statement, US National Academy of Sciences, 'Avoiding Unmanageable Climate Change', October 2009 (Cicerone, 2009).
>
> The presidents of 18 American scientific societies wrote to the US Senate urging action, and offering advice, on the ground that 'climate change is occurring, and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver'.[13]
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> 'Climate Change and the Integrity of Science', a 'Lead Letter', signed by 255 members of the US National Academy of Sciences, including 11 Nobel laureates, originally sent to the *Wall Street Journal* (Gleick et al., 2010).
>
> The Royal Society (UK), 'Climate change: a summary of the science', September 2010.

An overwhelming consensus of the world's top climate scientists and their professional organisations acknowledges that climate change poses serious risks to the well-being of large numbers of human beings if we continue 'business as usual' in our burning of fossil fuels.[14]

The most important international body of scientists (and policy experts) in this area is the United Nations Intergovernmental Panel on Climate Change (IPCC), which has issued numerous reports since its inception in 1988. Even though these reports, based on reviews of the scientific literature by hundreds of scientists from all countries in the United Nations, tend to be very conservative, they have been loudly criticised by global warming deniers for containing occasional errors. Given the meticulous and responsible manner in which the IPCC operates, it is absurd to deny credence to their findings – which show more and more that climate change is largely human-caused and likely to have consequences that are catastrophic if we do not act to mitigate the warming.[15]

In November 2008, James Hansen and eight co-authors published a paper titled 'Target Atmospheric CO_2: Where Should Humanity Aim?' where they write:

> If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 [parts per million] to at most 350 ppm. (p. 217)

At the United Nations climate conference in Copenhagen the following year, 112 countries endorsed the 350 ppm target, mostly the poorer nations who are already suffering from the effects of global warming. But since they are relatively powerless in geopolitical terms, their endorsements mean almost nothing: the most advanced nations, with the exception of a number of countries in Europe, are intent on continuing with business as usual. We reached, and surpassed, a CO_2 concentration of 350 ppm in 1988, and the figure at the end of 2012 was over 394 ppm.

Among the uncertainties that the science of ACC necessarily involves, most do not detract from the big picture, but one is of crucial importance: concerning the effect of the aerosols produced by fossil fuel burning. The warming from the increased concentrations of CO_2 is offset – but we cannot tell by how much – by a cooling from the release of aerosols in burning fossil fuels. In other words, the cooling from particulate air pollution is masking the warming effect of increased carbon dioxide. Air pollution is already a huge public health issue worldwide, and as the rate of burning continues to increase, there will be more frequent calls to reduce air

pollution because of its effect on public health.[16] In the worst case, as Hansen writes:

> If aerosols have been masking most of the greenhouse warming … and humanity reduces particulate pollution by even half, the net climate forcing would double. *That increased forcing, combined with a continued greenhouse gas increase, might push the planet beyond tipping points with disastrous consequences* [emphasis added]. The current smaller net climate forcing already is causing a notable recession of mountain glaciers around the world, affecting freshwater availability, shifting climatic zones, increasing fires and flooding, promoting the loss of Arctic sea ice and vulnerable coral reefs, accelerating mass loss from the Greenland and Antarctic ice sheets with rising sea level, and putting pressures on many species, leading to a danger of mass extinctions. (2010, pp. 99–100)

What makes the prospects terrifying is that some of these factors – the loss of sea ice in the Arctic and ice sheets in Greenland and Antarctica, together with the release of vast amounts of frozen methane as tundra melts – can reach climate 'tipping points', thresholds beyond which there's no way to reverse the changes. Hansen calls what pushes the situation towards tipping points 'amplifying feedbacks', also known as positive feedback loops.

In the case of ice loss, it is the 'albedo effect', whereby more of the incoming radiation from the sun is reflected back into space by the whiteness of ice than the blueness of sea: the more the ice melts, the more heat from the sun the planet absorbs. With the tundra, as the planet warms, the permafrost thaws and releases organic carbon trapped in the ice. The tundra contains an estimated 1,600 gigatons (Gt) of carbon – more than twice the amount currently in the atmosphere (Tarnocai et al., 2009). Much of the carbon is released in the form of methane, a heat-trapping gas that is 25 times more effective than carbon dioxide. This release of CO_2 and methane in turn increases atmospheric warming, which means more melting – and so forth, in a vicious spiral. What is unsettling here is that the warming effects from thawing permafrost have never been taken into account by the assessment reports on climate change issued by the IPCC. The United Nations Environment Programme (UNEP, 2012) published a report in November 2012 drawing attention to the syndrome and recommending that the IPCC study the issue.

A third syndrome that may lead to a tipping point involves droughts in the Amazon Basin. Some climate models suggest that global warming may be giving rise to more frequent and severe droughts there, which in turn initiate 'positive feedbacks that could lead to widespread Amazon forest degradation or loss'. This would transform the Amazon Basin from a

carbon sink into a huge *emitter* of CO_2. As the authors of a recent study in *Science* put it:

> The two recent Amazon droughts demonstrate a mechanism by which remaining intact tropical forests of South America can shift from buffering the increase in atmospheric carbon dioxide to accelerating it. (Lewis, Brando, Phillips, van der Heijden, & Nepstad, 2011, p. 554)

If we pass these tipping points, there's no way to prevent what the climate scientists call 'runaway global warming': even if we quickly stop burning fossils fuels, the feedback loops will spin the situation out of our control. As has happened before in the history of the earth's climate, the amplifying feedback that sets in after a tipping point is passed drives climate to an extreme of heat. Eventually the heat will evaporate the oceans and we end up with what Hansen calls 'the Venus Syndrome' – a fried planet with an atmosphere containing almost 97% carbon dioxide.[17]

There's a consensus in the climate sciences that we have to keep the planet's warming to under 2°C above pre-industrial levels, if we are to avoid exceedingly unpleasant consequences distributed unjustly among the world's various populations. Even though the UN Conference on Climate Change in Cancun in December 2010 was unable to achieve any binding agreements, the participating nations did manage a resolution 'to establish clear objectives for reducing human-generated greenhouse gas emissions over time to keep the global average temperature rise below two degrees' (Cancun Agreements). Although many climate scientists advise trying to keep the warming under 1.5°C rather than 2°C, the latest projections show that we are heading, in the absence of decisive action, to an increase by the year 2100 of 'about 4° to 6° above pre-industrial times' – where even the lower figure guarantees catastrophe (Global Carbon Project, 2012). A contemporary report from the International Energy Agency (IEA), 'Tracking Clean Energy Progress', says that

> achieving the transition [to the 2° scenario] is technically feasible, if timely and significant government policy action is taken, and a range of clean energy technologies are developed and deployed globally. (p. 5)

In December 2012, the executive director of the IEA, Maria van der Hoeven, issued the following warning to the participants of the UN Climate Conference at Doha:

> The need to rapidly transition to a more secure, sustainable global energy system is more urgent than ever. IEA analysis shows that achieving the internationally agreed climate goal of limiting warming to 2°C is becoming more difficult *and more expensive* with every passing year … . Yet even if the global temperature increase is limited to

> only 2°C, a warming planet may negatively affect our energy supply, demand and assets. In short, our energy security could be at risk. (para 1, emphasis added)

The problem is that the relevant governments show no interest in taking the 'timely and significant policy action' that would lead to a secure and sustainable global energy system – even though such action can be taken, given appropriate levels of investment. And so we will bequeath to our grandchildren a profoundly damaged world rife with chaos.

We are not dealing here with some vague and abstract hypothesis about how things could turn out: the changes that the climate models foresee – more frequent 'extreme weather events' for example – are already happening. In the United States, where denial of AGW is strongest and most widespread, two hurricanes just seven years apart, sisters Katrina (2005) and Sandy (2012), wreaked destruction to the tune of 150 billion dollars' worth of property damage. Climate scientists agree that it is premature to claim that global warming is the cause of the increase in extreme weather events we have seen over the past decade, but everything we know about the effects of higher temperatures on climate suggests that it is a major factor.

A rise in average temperatures means that the air can hold more moisture, which leads to rainstorms and flooding. Hurricanes and tropical cyclones may not get much more frequent with further global warming, but they are expected to become more intense and to bring heavier rainfall – which means greater destruction of people's livelihoods and homes (Knutson, 2008; Knutson et al., 2010). Warmer temperatures cause the oceans to expand, which leads to a rise in sea level, flooding of low-lying coasts, and salinisation of aquifers for drinking water. Although warming may improve growing conditions in some parts of the world for a time, it will disrupt agriculture elsewhere, promote desertification, expand the regions of the globe that are susceptible to tropical diseases, aggravate wars over resources, and thereby wreak prolonged mayhem. Climate models of what happens with global warming predict colder winters as well as more frequent droughts.

In view of this dismal scenario, where we visit a host of plagues upon innocent future generations, *what is to be done*? – Well, many people would say, and are saying: 'Nothing'. No need for any drastic changes in the way we consume energy.

CLIMATE SCEPTICISM

The rise to prominence of the climate sceptics and global warming deniers with their questioning of the scientific evidence for human-caused global

warming is a bizarre phenomenon with a variety of sources. It became possible only because of the extreme complexity of the climate sciences and some strange changes that have taken place in the United States in recent decades. The problem is compounded by a number of factors ranging from the psychological, through the sociological, economic and religious, to the political and geopolitical and the field of transgenerational ethics. Let us begin by looking at the development of the climate scepticism business (and it is a lucrative business) in the United States.

A Brief History

In 2008, two American political scientists and a sociologist published a paper titled 'The organisation of denial: Conservative think tanks and environmental skepticism' (Jacques, Dunlap, & Freeman, 2008). Their investigation into conservative think tanks concerned with environmental issues discovered that 90% advocated environmental scepticism, and their analyses of over 140 'climate-sceptical' books, most of them published in the United States since 1992, revealed that over 92% of them were linked to conservative think tanks. Among such institutions, the most prominent are the George C. Marshall Institute, the American Enterprise Institute, the Heritage Foundation, the Cato Institute, the Competitive Enterprise Institute, and the Heartland Institute. Owing to the leaking of some internal documents from Heartland in February 2012, we now know what was long suspected: that it receives funds from fossil fuel concerns and one anonymous donor (of almost $9 million over four years recently) for its 'climate change' conference series, as well as plans for a consultant to develop a 'global warming curriculum' for schools – one that 'shows that the topic of climate change is controversial and uncertain'.[18]

An exemplary institution for the business of scepticism about science more broadly is the Marshall Institute, whose slogan on the masthead of its website is 'Science for Better Public Policy'. Three prominent physicists were involved in the Institute's founding in 1984: Robert Jastrow, William Nierenberg, and Frederick Seitz. One of the Institute's first major projects was to promote Ronald Reagan's 'Strategic Defense Initiative', better and more aptly known as the 'Star Wars' fantasy, and to defend its feasibility against the attacks from the majority of scientists – which eventually led to its demise. A cultural-historical analysis of the activities of the three Marshall Institute physicists shows them to have enjoyed

enormous influence on politicians and policy makers, yet also to have held on to outmoded cultural values concerning science, technology and society, values that were threatened by on-going discoveries concerning the environment (Lahsen, 2008). As Clive Hamilton puts it, in the course of a discussion of the conservative activist Dixy Lee Ray: 'their anxiety over national sovereignty was matched by the disquiet they felt at environmentalism's destabilization of the idea of progress and mastery of nature' (2010, p. 100).[19]

Along with another physicist, Fred Singer, who is still active on behalf of contrarian concerns, the Marshall Institute 'trio' vigorously lobbied against a series of initiatives designed to protect public health and the natural environment. They questioned the links between smoking (and 'second hand smoke') and lung cancer, the contribution of coal- and oil-fired power stations to the production of acid rain, the role of chlorofluorocarbons in ozone depletion, and more recently and energetically the human contribution to global warming. In each case, they dismissed the scientific consensus as 'bad science', or 'junk science', and advocated instead – with a confident zeal that would have amazed George Orwell – their own contrarian 'sound science' instead.

However, their activities consist not in doing scientific research of their own but rather in 'merchandising doubt', as Naomi Oreskes puts it, whose book with Erik M. Conway gives a meticulous account of this long and dismal tale of deceit (Oreskes & Conway, 2011; see also Hoggan, 2009). A banner at the foot of the Marshall Institute's home page reads, 'Responding to Oreskes and Conway's *Merchants of Doubt*': click on it and you're taken to a page with links to three responses to the book, authored by the President, the Director, and the CEO of the Institute.[20] Predictably, they dismiss the book as 'not history, [but] a one-sided polemic', but they make no attempt to respond to its arguments or refute the evidence that its authors provide. As a professor of history and science studies at the University of California, San Diego, Oreskes has great credibility and a huge professional stake in getting the facts right and making her arguments sound.

A rare 'insider' perspective on the Marshall Institute is provided by the author Matthew B. Crawford, who was appointed executive director in 2001, but resigned after five months. He had discovered the position was 'not to [his] taste' because:

> the trappings of scholarship were used to put a scientific cover on positions arrived at otherwise. These positions served various interests, ideological or material. For example, part of my job consisted of making arguments about global warming that just

> happened to coincide with the positions taken by the oil companies that funded the think tank. (2010, p. 82)

As Oreskes and Conway have pointed out, there *is* no 'disagreement' about the science of global warming, because that is not how the sciences work. They are a fundamentally collective enterprise that advances knowledge through the process of peer review. The Marshall Institute physicists had no expertise in the climate sciences, and instead of publishing research in peer-reviewed journals, they chose to disagree with the scientific consensus of experts in the forum of public opinion and policy making.

The hypothesis that the burning of fossil fuels is the major factor causing the planet to heat up is especially strong because of its fit with evidence from such a wide range of other sciences: with the physics of the selective absorptivity of greenhouse gases, and the findings of palaeogeography, palaeogeology, palaeobiology, palaeobotany, and above all with palaeoclimatology. This last branch of natural science correlates evidence of meteorological conditions with other processes on the earth record, and in this way can account for almost all periods of warming and cooling in the earth's history with only a few anomalies. While there are always uncertainties, the sceptics' claim that more research is needed, or that what the experts in climate science are telling us is wrong, is absurd – since it is inconceivable that everything the physical sciences have been telling us about the natural world since the seventeenth century could turn out to be false.

The grateful embrace of doubt about global warming by an indolent public is possible only on the basis of a misunderstanding of how the natural sciences work, a problem that is aggravated by the variety of the climate sciences and the complexity of their findings. This means that, since scientists usually specialise in a particular area of research, only a very few climatologists command an overview of the entire field that would allow them to be effective communicators of its findings to the public. On the other hand, the complexity of the climate sciences makes it possible for clever global warming deniers to seem at first blush as if they are making scientific sense, when in fact their presentations are full of misinterpretations, mistakes, misleading statistics and downright lies. But the surface of their presentations is so slick that it is hard for non-experts to discern the deception.

Two features of natural science are especially misunderstood: the role of *certainty* and the nature of *causality*. Climate sceptics say that the scientific evidence of AGW is not yet sufficient to warrant certainty. Politicians love

to hear this, since it allows them in turn to say (as George W. Bush said throughout the six years of his presidency): 'We need to wait until the science of global warming is certain'. This is nonsense, because certainty is unattainable in the climate sciences. Meteorology, oceanography and climatology are not in a position to perform laboratory experiments to test their hypotheses. The laboratory would have to be the entire biosphere, where too many variables abound to permit controlled experiments.

Instead the climate sciences use statistics to calculate probabilities, and employ computer modelling to try to understand patterns of climatic change. When considering what action to take in the face of uncertainty, climate scientists (and scientists in many other fields) recommend following the 'Precautionary Principle'. This says that, in situations where scientific evidence gives us good reason to suppose that certain activities will prove harmful in the long run, the burden of proof should lie with those proposing to undertake or continue such activities, and that action should be taken to prevent or minimise harm even when the scientific evidence does not provide full certainty. At the UN 'Earth Summit' in 1992, representatives from 194 nations agreed that, 'In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities' (United Nations Framework Convention on Climate Change, 1992, article 3, section 15).[21] So, to say that we should wait because the science is not yet certain is to miss the point completely. It would be like waiting for Godot, except that the stakes are higher.

As for causality, we tend to take examples from Newtonian physics as the paradigm, where a single cause brings about a single effect: the impact of the white billiard ball causes the red one to roll across the baize and into the pocket. But events in nature are rarely that simple: usually an event is brought about by multiple causes in dynamic interaction, as when a tropical storm results from a confluence of many weather conditions. The causality behind the urgent questions in epidemiology and public health are often of this nature: although we may be able to determine that the presence of a certain bacterium in the water supply is causing a certain disease, it is very hard to prove that industrial chemicals being discharged into a river are causing leukaemia and cancers in the local population. Similarly with cigarette smoking and lung cancer – a fact that allowed the tobacco companies to deny that smoking causes cancer, since strictly speaking we can only say that the greater the number of cigarettes smoked, the more likely the smoker is to develop the disease.

One often hears the objection, 'Carbon dioxide is only *correlated* with temperature, and there's no proof that higher concentrations of greenhouse

gases actually *cause* rises in the earth's temperature'. Numerous websites devoted to denying anthropogenic climate change prominently display this falsehood on their front pages. What John Tyndall discovered about the selectively absorptive properties of carbon dioxide and other greenhouse gases has never been refuted, and it fits with everything else physics tells us about the interactions between solar radiation and gases in the atmosphere. Although there are other, minor factors also at work, there can be no reasonable doubt that these heat-trapping gases are major contributors to the rise in temperatures.

Psycho-Social Factors

Another problem with global warming which makes the sceptics' job easier is its *abstract* nature: it is a phenomenon whose dangers are not immediately manifest, where the risk is incremental and not directly perceptible by the senses. The rise in global temperatures is in any case very gradual, and accompanied by geographical fluctuations.

Human beings evolved over millions of years in hostile environments, and those of us who have survived have done so because our ancestors developed effective physical responses to imminent threats of harm. But the dangers from global warming are more distant and diffuse: indefinite in their timing, and uncertain in their effects on any particular individual. We tend to be lazy: we are creatures of habit and so dismiss information, or resist forces, that would oblige us to change our ways. And the habits that help us negotiate the difficulties of daily life are of no help when it comes to dealing with climate change. We also prefer effort to be closely followed by gratification, and so are reluctant in the case of global warming to forgo present pleasures for the sake of future generations – since most of these do not even exist yet.

The American Psychological Association, aware of the strength of psychological barriers to taking action on climate change, set up a task force to investigate the issue. Its report, 'Psychology and Global Climate Change' (2010), discusses several such barriers:

> Many … [people] are unaware of the problem, unsure of the facts or what to do, do not trust experts or believe their conclusions, think the problem is elsewhere, are fixed in their ways, believe that others should act, or believe that their actions will make no difference or are unimportant compared to those of others. (p. 8)

The report concludes by offering a number of research and policy recommendations in response to such problems.

Sociological studies suggest that cultural values and conformity to the views of one's social group – which condition 'what kind of person one is' – play a major role in determining what one makes of the evidence for ACC. Whether you identify yourself as an individualist or a communitarian, for example, makes a difference to the conclusions you draw from the evidence. Dan Kahan (2012) and others have pointed out that the 'costs' to the individual citizen of not agreeing with the scientific consensus on climate change are zero, while the costs of not conforming with the members of one's social group can be high. It is therefore quite rational under such circumstances to conform (Kahan, 2012, p. 255).[22]

Surprisingly, these studies show further that the more scientifically literate and numerate the individual, the more likely he or she is to become *more* polarised pro or con on the question of ACC. This suggests that cultural conformity with one's social group – together with 'the citizens' effective use of their knowledge and reasoning capacities to form risk perceptions that express their cultural commitments' – is a deeper and more powerful motivator than the common good, whether of the society or humanity as a whole.[23] This points up the shortcomings of any ethics that is focused on the smaller social group rather than the society, or the planet, more broadly.

Another factor here is the strange change that has taken place in the United States with respect to the status of natural scientists. Just 10 or 20 years ago, the general public trusted and respected its scientists, especially when they appeared on television wearing white lab coats. One reason for the change is that debates within the scientific community used to take place 'in private', as it were: the public would see only the generally agreed on results of scientific inquiries. But now the conservative think tanks have the finances and political connections to ensure that any missteps on the part of climate scientists are widely and shrilly reported in the media. The media have not served the public interest well in this area, as evidenced in the so-called 'Climategate fiasco'. On the basis of leaked emails from a number of climate scientists, a scandal was fomented in the press over alleged misconduct and skulduggery. Global warming deniers exploited this event shamelessly, encouraging the public to believe that most, if not all, climate scientists were liars and crooks. Subsequent independent investigations exonerated the scientists of any professional wrongdoing, but this was only very quietly reported in the media.[24]

Apart from the restricted sphere of their direct experience, the main way people 'know' about the world is through the mass media: newspapers and books, television, radio and the Internet. But the complexities of climate

change do not lend themselves well to representation in such media, and if, as often happens, television affords equal opportunity to the climate sceptics and global warming deniers (in the interests of 'fair and balanced' reporting), this gives the false impression that the scientific community is more or less evenly divided on the issue – which, of course, it is not. What is more, many of the media can be 'bought' by parties with vested interests in preventing the bad news about fossil fuel burning from reaching the public. Some media have already been bought: witness the power of someone like Rupert Murdoch (in the news himself in 2012 because of the *News of the World* phone-hacking scandals) to influence public opinion.

The 'Climate Change and the Integrity of Science' letter mentioned earlier, signed by 255 members of the US National Academy of Sciences, was first sent to Murdoch's *Wall Street Journal*, which declined to publish it. Instead, the *WSJ* saw fit to run an 'Opinion' piece with the reassuring title, 'No Need to Panic about Global Warming: There's no compelling scientific argument for drastic action to "decarbonize" the world's economy'. The piece was signed by 16 scientists, none of whom is a prominent climate scientist and only three of whom appear to have anything to do with the climate sciences.[25] This publication unleashed a storm of criticism, led by a letter to the editor by 38 of the world's top climatologists who pointed out the authors' lack of relevant qualifications. Asking advice from that group about climate change would be like consulting your dentist about a heart condition:

> While accomplished in their own fields, most of these authors have no expertise in climate science. The few authors who have such expertise are known to have extreme views that are out of step with nearly every other climate expert.[26]

As several commentators have confirmed, the *WSJ* Opinion piece is full of factual errors, specious claims and misleading representations. An especially egregious misrepresentation concerns the eminent economist William Nordhaus.

Economics

In 'No Need to Panic' the "Wall Street Sixteen" wrote the following:

> A recent study of a wide variety of policy options by Yale economist William Nordhaus showed that nearly the highest benefit-to-cost ratio is achieved for a policy that allows 50 more years of economic growth unimpeded by greenhouse gas controls. (para 12)

And Professor Nordhaus's response:

> The piece completely misrepresented my work. My work has long taken the view that policies to slow global warming would have net economic benefits, in the trillion of dollars of present value. This is true going back to work in the early 1990s (MIT Press, Yale Press, Science, Proceedings of the National Academy of Science, among others). I have advocated a carbon tax for many years as the best way to attack the issue. (Revkin, 2012, para 13)

As often happens in such situations, the *Wall Street Journal* did not (as far as I know) correct the gross misrepresentation of Nordhaus's position, or any of the other errors the piece contained, and since the letter from the Climate Sciences Thirty-Eight does not mention Nordhaus, most readers will come away with completely the wrong impression of his position. He did, however, go on to deliver a comprehensive refutation of the sceptics in a long essay in the *New York Review of Books* (Nordhaus, 2012; see also Nordhaus, Cohen, Happer, & Lindzen, 2012).

Until recently, the environmental costs of doing business were largely ignored, since the natural world was thought to be vast enough to act as a bottomless 'sink' for the wastes produced by human industrial activity.[27] Sewage was discharged untreated into the sea, by-products of manufacturing processes were poured into rivers and lakes, and chemical pollutants and soot were spewed into the atmosphere – all on the assumption that the environment would absorb them well enough to forestall adverse effects on humans. But it soon became clear that this assumption was untenable, and that it makes sense to 'internalise' costs to the environment. If I operate a factory that discharges toxic waste into a nearby river, the damage to the environment and the neighbouring community is what economists call a 'negative externality', since it is borne by people and things that stand outside the economic transactions between me (as owner of the factory) and my customers. If instead I pay another company to remove the toxic waste on a regular basis, and incorporate the expense into the cost of what the factory produces, I am thereby 'internalising' the costs to the environment. This would be an example of the 'polluter pays' principle, which is widely regarded as fair enough – although companies often do not observe it if they think they can get away with it.

The 'Rio Declaration on Environment and Development', a document that arose from the UN 'Earth Summit' in 1992, contains an eminently sensible principle titled 'Internalization of Environmental Costs', which reads as follows:

> National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the

> polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment. (The United Nations Conference on Environment and Development, 1992, Principle 16)

However, despite the fact that most of the consequences of global warming are against 'the public interest', the fossil fuel burning industries continue to assign their waste products, in the form of CO_2, to economic externalities. The world would be a very different place if economies included environmental costs (which include harm to humans) as internalities. A tax on carbon would be the obvious way to start, as Nordhaus and other economists have been suggesting for some time. Under the present circumstances, as the British economist Nicholas Stern put it in his report on *The Economics of Climate Change*: 'Climate change presents a unique challenge for economics: it is *the greatest example of market failure we have ever seen*.'[28] It is a failure because it is naïve to believe that we can continue to treat the atmosphere as 'an open sewer' into which we can pour our wastes without incurring crippling costs in the longer term.[29]

This is precisely what the 'merchants of doubt' examined by Oreskes and Conway refuse to acknowledge: what underlies and drives their contrarian resistance to scientific evidence is a fanatical adherence to 'free market fundamentalism', the belief that a laissez-faire capitalism that keeps markets free of government regulation is the only viable economic system.[30] It has proved viable for a while – though at great expense to non-capitalists and the natural environment – but its days are clearly numbered.

Two years after winning the Nobel Prize in Economics, Paul Krugman wrote a long essay for the *New York Times* titled 'Building a Green Economy', which he begins by remarking on the similarity between the debate over the science of climate change and the economic debate over the costs of continuing with business as usual versus taking action to avoid catastrophic economic consequences.

> The casual reader might have the impression that there are real doubts about whether emissions can be reduced without inflicting severe damage on the economy. In fact, once you filter out the noise generated by special-interest groups, you discover that there is widespread agreement among environmental economists that a market-based program to deal with the threat of climate change – one that limits carbon emissions by putting a price on them – can achieve large results at modest, though not trivial, cost. (para 3)

Although Krugman opts for a different policy solution from Nordhaus's, he too argues that immediate economic action to reduce greenhouse-gas emissions is crucial, and would cost the world economy little by comparison with the price we pay if we delay. Comparing the costs of reducing emissions and mitigating greater damage later: 'Climate change will lower

gross global product 5 percent, stopping it will cost 2 percent' (para 60). Krugman acknowledges the extreme complexity of the issue, which renders all predictions uncertain – but argues that in any case the significant risk of utter catastrophe must override simple cost-benefit calculations and requires strong climate policy to reduce emissions.

So why are the oil, gas and coal industries – let us call them 'the fossil fuel concerns' since they are going the way of the dinosaurs – so vehement in their opposition to the news about AGW and so wilfully blind to the arguments of the environmental economists? It was evident decades ago that the rational way for these industries to serve the public interest while at the same time maximising profits would have been – in view of pollution problems and the finite supply of fossil fuels – to reconfigure themselves as energy suppliers rather than fossil fuel burners. But they are obliged to maintain their 'see no evil' stance because profits have to come before the public interest, and their investments in fossil fuels are too huge. As Krugman remarks, public policy is obliged to take a far longer view of the situation than private markets.

On one hand, there are what business-people call the 'sunk costs' of the current fossil fuel infrastructure (from oil rigs in the Gulf of Mexico to pipelines and supertankers, coal mines and power plants) which have been estimated at over $10 trillion worldwide – a sum of money beyond the capacity of most of us to even imagine. That infrastructure is going to be around for up to 50 years before the capital costs will be paid off, and so, as Bill McKibben bluntly puts it, 'If we shut that infrastructure down early, merely to prevent ourselves from frying the planet, someone will have to eat those costs' (2011, p. 55).

On the other hand, there is the prospect of 'stranded assets' among the resources the fossil fuel concerns have their hands on but have not yet put on the market, and this poses a far larger financial problem. According to a report by the Carbon Tracker Initiative in London, the currently known fossil fuel reserves on the planet – listed on public company balance sheets and reports by the state-owned concerns in countries like China, Russia, Iran, and Venezuela – contain a total of 2,795 Gt of carbon dioxide: 65% from coal, 22% from oil, 13% from gas (Leaton, n.d.). The good news, for the fossil fuel concerns, is that these reserves are worth an estimated $27 trillion (Fullerton, n.d.). The bad news, for the rest of the human race, is that if these resources are sold and used, the planet will become uninhabitable.

Now consider this in the context of the scientific consensus that, if average global temperatures rise more than 2°C from pre-industrial levels, the

effects on tropical disease vectors, desertification and drought, sea-level rise and floods, freshwater supplies and food production, will be catastrophic. (Many experts think that an increase of even 1.5°C would have disastrous consequences.) We have already seen an increase of 0.6°C, and are beginning to experience its effects in the form of the 'extreme weather events' that the climate models lead us to expect.

There were high hopes that the conference convened by the United Nations Framework Convention on Climate Change in Copenhagen in 2009 would finally, with the expiration of the Kyoto Protocol imminent, lead to some meaningful and binding agreement to slow global warming, but, mainly owing to lack of cooperation on the part of the United States and China, it did not. If there was a high point anywhere in those depressing proceedings, it was the acknowledgment in the (non-binding) 'Copenhagen Accord' of the scientific view that average temperatures should be kept below 2°C. Those nations that are already experiencing the adverse effects of global warming, the Alliance of Small Island States and the least developed countries, recommended for good reason a limit of 1.5°C. The conference as a whole agreed to review in four years the question of the limit to aim for.

In 2010, the United Nations Environment Programme (UNEP, 2010) published a document, 'The Emissions Gap Report', showing that, even if nations followed through on their (non-binding) pledges, it would be unlikely that even the 2°C increase could be avoided (UNEP, 2010). Nevertheless, the follow-up to Copenhagen, the UN Conference on Climate Change in Cancun in December 2010, was unable to achieve any binding agreements, only a resolution 'to establish clear objectives for reducing human-generated greenhouse gas emissions over time to keep the global average temperature rise below two degrees' (Cancun Agreements, 2010, first objective).

Research by the Potsdam Institute for Climate Impact Research in Germany, the foremost institute of its kind in the world, has estimated the upper limit to CO_2 emissions if we are to reduce to 20% the chances of exceeding a 2°C warming. The resulting 'carbon budget' for the years 2000–2050, the amount we can afford to burn without risking catastrophe, is 886 Gt (Meinshausen et al., 2009). Since we have already emitted, through fossil fuel burning and changes in land use, over 320 Gt in the century's first decade, this leaves a budget of around 565 Gt for the years up to 2050 (Leaton, n.d., p. 6). The IEA, in its *World Energy Outlook* for 2011, points out that four-fifths of the carbon budget to 2035 are already locked in place by capital investment in existing infrastructure (power

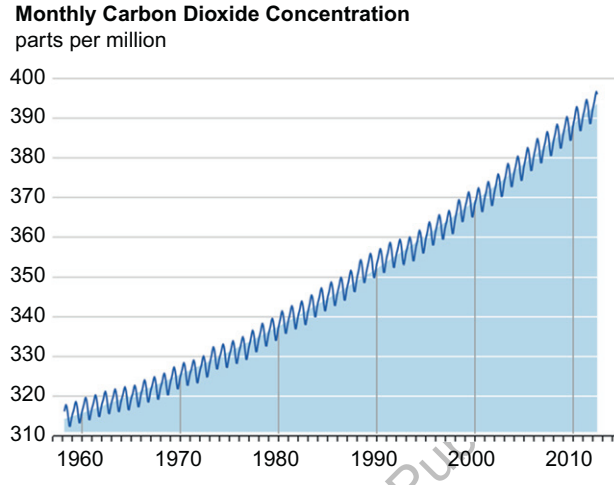
plants, factories, etc.), so that the 2°C warming is becoming ever harder to avoid – and a 6°C warming is the likely outcome if we continue with business as usual (International Energy Agency and Organisation for Economic Co-operation and Development, 2011).

Bill McKibben recently laid out many of these considerations with admirable clarity and concision in an essay titled 'Global Warming's Terrifying New Math' in *Rolling Stone* (McKibben, 2012). He points out that since the known fossil fuel reserves (2,795 Gt) are five times the amount that the climate scientists say is safe to burn (565 Gt), around 80% of them will have to stay in the ground – which would mean a loss of some $20 trillion to the fossil fuel concerns. Add to that whatever percentage of the $10 trillion in existing infrastructure has not been paid off yet, and it is no wonder they are fighting so hard to persuade people that global warming is not our (or their) fault.

The second part of this essay considers the major obstacles to taking action on global warming and evaluates various proposed solutions.

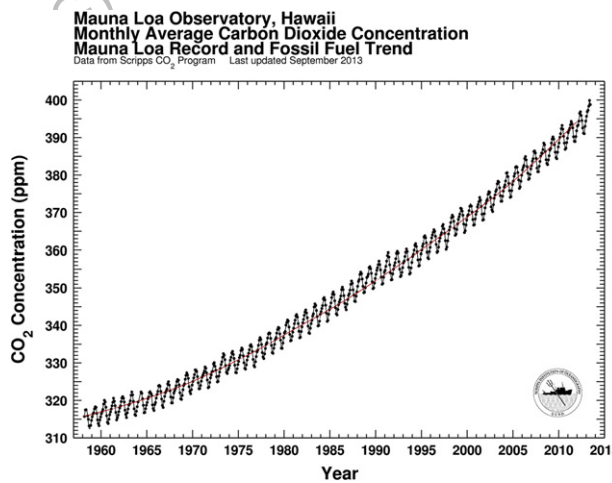
NOTES

1. I would like to thank John Barry of Queens University Belfast for helpful comments on an earlier draft of this paper. I am aware of the terminological shift from talking about 'global warming' to discussions of 'climate change', but will use both terms in what follows, as well as the abbreviations for the human-caused versions (AGW for anthropogenic global warming and ACC for anthropogenic climate change). Though the changes brought about by the warming include colder winters and other extremes of climate, the warming remains the fundamental reality.
2. See, for example, Gallup and Newport (2010).
3. See, for example, Kasser (2003), Graham (2011, 2012), and Bok (2011).
4. See Dyer (2011) for an array of depressing facts and possible scenarios.
5. Atiq Rahman, executive director, Bangladesh Centre for Advanced Studies, cited in Dyer (2011).
6. The concentrations of CO_2 are measured and calculated at the Earth Systems Research Laboratory in Hawaii (Tans & Keeling, n.d.).
7. A picture of this magnificent device can be seen at http://doc-snow.hubpages.com/hub/Global-Warming-Science-In-The-Age-Of-Queen-Victoria.
8. See the website of the CO_2 program at the Scripps Institution of Oceanography at the University of California San Diego: http://scrippsco2.ucsd.edu/graphics_gallery/mauna_loa_record/mauna_loa_record_-_color.html; accessed on 23 August 2012. For the latest figures, see http://co2now.org/; accessed on 12 January 2013.



9. See Petit et al. (1999). See the chart of temperature and levels of carbon dioxide and methane in Chapter 2 of Intergovernmental Panel on Climate Change (2001).

10. Black (zigzag) curve: Monthly average atmospheric carbon dioxide concentration versus time at Mauna Loa Observatory, Hawaii (20°N, 156°W) where CO_2 concentration is in parts per million in the mole fraction (ppm). The curve is a fit to the data based on a stiff spline plus a 4 harmonic fit to the seasonal cycle with a linear gain factor. Red curve: Fossil fuel trend of a fixed fraction (57%) of the cumulative industrial emissions of CO_2 from fossil fuel combustion and cement production. This fraction was calculated from a least squares fit of the fossil fuel trend to the observation record. Data from Scripps CO_2 Program. Last Updated October 2009 (http://scrippsco2.ucsd.edu/program_history/keeling_curve_lessons_3.html).



11. See also the earlier analysis by Oreskes (2004).

12. Hansen et al. (2008), *Storms of My Grandchildren: The Truth about the Coming Climate Catastrophe and Our Last Chance to Save Humanity*. The wordy subtitle sounds more like the publisher than Hansen, but the body of the text is sober in its elucidation of the scientific issues and comprehensive documentation of the dangers. For some literature by authors whose work is well grounded in up-to-date evidence from the climate sciences, see Kolbert (2006); Monbiot (2007); McKibben (2011); Hamilton (2010); and Hertsgaard (2012).

13. The American Association for the Advancement of Science, American Chemical Society, American Geophysical Union, American Institute of Biological Sciences, American Meteorological Society, American Society of Agronomy, American Society of Plant Biologists, American Statistical Association, Association of Ecosystem Research Centers, Botanical Society of America, Crop Science Society of America, Ecological Society of America, Natural Science Collections Alliance, Organization of Biological Field Stations, Society for Industrial and Applied Mathematics, Society of Systematic Biologists, Soil Science Society of America, University Corporation for Atmospheric Research; Letter available for viewing at: http://www.ucsusa.org/assets/documents/ssi/climate-change-statement-from.pdf, accessed 1 September 2012.

14. For a concise account, see Rockström et al. (28 distinguished co-authors) (2009).

15. For an excellent account of the IPCC, see Bolin (2008). See also footnote 29* in *The Politics of Global Warming (2): Two Obstacles to Circumvent* for an example of the IPCC's modus operandi.

16. Hansen (2010). A comprehensive study published by *The Lancet* estimates that pollution from cars caused over 2 million premature deaths in east and south Asia during 2010 (Lim et al., 2012). According to a report by the Organisation for Economic Co-operation and Development, we can expect 3.6 million premature deaths from ground-level ozone pollution alone by 2050 (OECD, 2012).

17. Hansen, 2010, Chapter 10, 'The Venus Syndrome'.

18. Hickman (2012); the documents, fraudulently obtained, are posted at Demelle, 2012. The institute has claimed that the 'Climate Strategy' memo is faked, but has provided no evidence.

19. See also his insightful account of climate change denial, pp. 95–133.

20. The Marshall Institute – Responding to Oreskes and Conway's Merchants of Doubt (n.d.).

21. Section 3 reads: "The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. *Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures* … taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost." (Emphasis added)

22. "So, if the cost of having a view of climate change that does not conform with the scientific consensus is zero, and the cost of having a view that is at odds with members of one's cultural community can be high, what is a rational person to do? In that situation, it is perfectly sensible for individuals to be guided by modes of reasoning that connect their beliefs to ones that predominate in their group. Even people of modest scientific literacy will pick up relevant cues. Those who know

more and who can reason more analytically will do a still better job, even if their group is wrong on the science."

23. Kahan et al. (2011). See also the section titled 'Values determine beliefs' in Hamilton (2010, 107ff).

24. The eight major investigations covered by secondary sources include the following: The House of Commons Science and Technology Committee (United Kingdom); Independent Climate Change Review (United Kingdom); International Science Assessment Panel (United Kingdom); Pennsylvania State University first panel and second panel (United States); United States Environmental Protection Agency (United States); Department of Commerce (United States); National Science Foundation (United States). Listed in Climate Research Unit email controversy, 2013.

25. Claude Allegre et al. (2012), "No Need to Panic about Global Warming."

26. The text of the letter and list of signatories can be read at Johnson (n.d.).

27. For an excellent account of the economic issues involved here, as well as the politics associated with them, see Barry (2012).

28. Stern has recently expressed regret that in fact the situation is far worse than he realised when writing that book: Stewart and Elliott (2013).

29. Peter Singer (2004) makes the analogy between emitting greenhouse gases and pouring our wastes into a huge sink in *One World: The Ethics of Globalization*, 27ff. Al Gore (2010) used the term 'open sewer' in an op-ed piece, 'We can't wish away climate change', in the *New York Times*.

30. Oreskes and Conway (2011, pp. 248–55). The term 'free market fundamentalism' comes from Soros (1998).

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