Elk River Wind Project, Butler County, Kansas.

Excerpted from *The Rough Guide to Climate Change* by Robert Henson. Copyright 2011 Robert Henson. Permission granted by Rough Guides Ltd. http://amzn.to/wc5mWy

A heated debate

How scientists, activists, sceptics and industry have battled for column inches and the public mind

In recent years, perhaps no realm of science has found itself under as much scrutiny as climate change. That's no surprise: at its heart, the issue counterposes the future of our planet's atmosphere and ecology against the most profitable industries on Earth – those that extract, refine and sell fossil fuels. But there are many other reasons why global warming has been such a contentious topic for more than twenty years. The main cause, carbon dioxide, is literally invisible. The worst effects may occur many thousands of kilometres from where we live, or many decades from now. And unlike environmental problems that can be pinned on a few bad actors, virtually all of us produce greenhouse emissions through the course of our daily lives. All of these factors make it tempting to try to refute, dismiss or ignore climate change rather than confront its profound implications head on.

Global warming politics didn't catch fire at first. For the most part, the topic remained in the scientific background until it became clear that the rise in greenhouse gases was real and serious. Even as research (and the gases themselves) continued to accumulate, it took other events to light the fuse in the late 1980s and make climate change a top-level global concern. That's when industry saw the potential threat to its profits and began to act. Starting around 1990, many oil, coal, gas and car companies and like-minded firms joined forces to sow seeds of doubt about climate change science. Working along similar lines as these companies (and, in some cases, getting funded by them directly or indirectly) was a tiny subset of contrarians – scientists of various stripes who bucked the research mainstream and downplayed the risk of global warming. Facilitated by a media

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eager to produce "balanced" coverage, this small group of scientists became familiar to anyone reading or hearing about climate change. At the other end of the spectrum, environmental activists argued passionately for the defence of the planet and its ecosystems, often with colourful protests tied to key diplomatic moments.

The landscape of climate-change debate has grown far more complex since the Kyoto Protocol – the first global agreement to reduce greenhouse-gas emissions – was introduced in 1997. While the issue is often portrayed as a one-side-versus-the-other battle, there's plenty of nuance in the mix, even among those who agree on the big picture. Many corporations have taken up the banner of reducing emissions, in order to save on their energy costs as well as burnish their green credentials. And environmentalists have fiercely debated many angles among themselves, including the pace at which emissions ought to be reduced and the merits of nuclear power in a greenhouse-threatened world. The scene grew even more muddled in 2009–10, as a batch of emails leaked from top climate scientists triggered controversy, while international squabbling dimmed the chance of a new global agreement on emissions reduction. All this has unfolded despite the fact that the world's leading scientific societies – including the national academies of more than 30 countries – stand firmly behind the recognition that humans are changing the climate.

Greenland is now a major breeding ground for North Atlantic icebergs. Is it on the way to becoming as torrid as South Carolina?

Is the World Getting Warmer?

By ALBERT ABARBANEL and THORP McCLUSKY

Was this past mild winter just part of a natural cycle? Will the old-fashioned blizzard someday disappear? Here are the startling facts revealed by world-wide weather surveys now going on.

FOR the past three winters a colony of Penobscot Indians who live on an island in the Penobscot River, near Old Town, Maine, have been plagued by unseasonable thaws. Since time immemorial, the tribe has used the ice as a bridge to the mainland from November until April, walking back and forth and even driving trucks and automobiles on sawdust laid across the slippery surface. Until recently the ice had never gone out in January, as the memories of older tribesmen and the results of annual betting pools on the day and hour of the spring breakup attested.

But since 1948 there has been a January thaw every year – to the astonishment of Indians and Old Towners alike. In 1949 the ice went out so suddenly

Climatologist Hans Ahlmann asserts that the earth is undergoing a change toward greater warmth.

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This *Saturday Evening Post* article from 1950 was one of the very first stories on climate change in the popular press.

The early days

As we've seen, the greenhouse effect was discovered right back in the nineteenth century, but serious scientific and media debate about climate change didn't take off until much later. One of the first news stories came in 1950, after global temperatures rose from around 1900 to the 1940s. *The Saturday Evening Post*, then one of the US's biggest magazines, asked a question one might hear today: "Was this past mild winter just part of a natural cycle?" Their article "Is the World Getting Warmer?" rounded up a variety of anecdotal evidence, including "tropical flying fish" sighted off the New Jersey coast. As possible

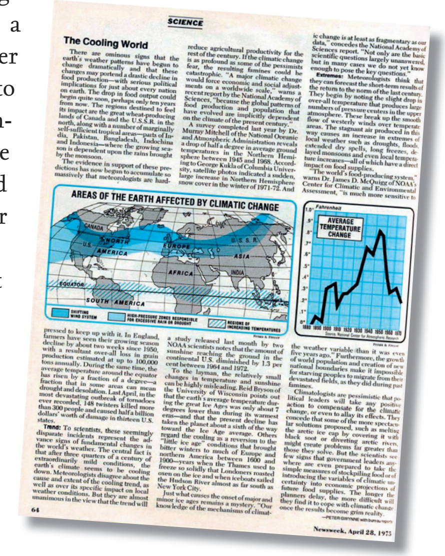
causes for the warm-up, the article cites solar variation and other natural factors. Greenhouse gases aren't even mentioned.

> **"Climatological Cassandras are becoming increasingly apprehensive, for the weather aberrations they are studying may be the harbinger of another ice age."**
> ***Time* magazine, 1974**

The scientific debate picked up in the 1960s. But at that time, there was plenty else to worry about – nuclear annihilation, for instance – so few people outside of scientific circles heard much about the risk of climate chaos. Things began to change in the 1970s, when the embryonic environmental movement called out air pollution as an example of humans' soiling of the planet. With early photos from outer space now highlighting Earth's stark aloneness, it was suddenly easier to believe that humans could affect the atmosphere on a global scale.

But what grabbed most of the press in the 1970s wasn't a global warming but a cool-down. Earth's temperature had been gradually slipping for some three decades, mainly in the Northern Hemisphere. A few maverick scientists speculated that dust and sun-blocking sulphate particles emitted from North America and Eurasia could be responsible for the cooling. A British documentary in 1974 called *The Weather Machine* warned that a single brutal winter could be enough to plaster northern latitudes with a "snow blitz" that the next summer couldn't entirely erase, thus leading to continent-encrusting ice sheets within decades. If nothing else, climate had started to seem more fluid and unstable than most people had ever thought possible.

Even as reporters chattered about cold, many scientists were concerned about the long-term outlook for warmth. In a 1972 *Nature* paper entitled "Man-made carbon dioxide and the 'greenhouse effect'", J.S. Sawyer predicted a temperature rise of 0.6°C (1.0°F) for the rest of the twentieth century – a figure that was only slightly off the mark. A landmark 1975 paper in *Science* by



SCIENCE

The Cooling World

There are ominous signs that the earth's weather patterns have begun to change dramatically and that these changes may portend a drastic decline in food production—with serious political implications for just about every nation on earth. The drop in food output could begin quite soon, perhaps only ten years from now. The regions destined to feel its impact are the great wheat-producing lands of Canada and the U.S.S.R. in the north, along with a number of marginally self-sufficient tropical areas—parts of India, Pakistan, Bangladesh, Indochina and Indonesia—where the growing season is dependent upon the rains brought by the monsoon.

The evidence in support of these predictions has now begun to accumulate so massively that meteorologists are hard-pressed to keep up with it. In England, farmers have seen their growing season decline by about two weeks since 1950, with a resultant over-all loss in grain production estimated at up to 100,000 tons annually. During the same time, the average temperature around the equator has risen by a fraction of a degree—a fraction that in some areas can mean drought and desolation. Last April, in the most devastating outbreak of tornadoes ever recorded, 148 twisters killed more than 300 people and caused half a billion dollars' worth of damage in thirteen U.S. states.

Trend: To scientists, these seemingly disparate incidents represent the advance signs of fundamental changes in the world's weather. The central fact is that after three quarters of a century of extraordinarily mild conditions, the earth's climate seems to be cooling down. Meteorologists disagree about the cause and extent of the cooling trend, as well as over its specific impact on local weather conditions. But they are almost unanimous in the view that the trend will reduce agricultural productivity for the rest of the century. If the climatic change is as profound as some of the pessimists fear, the resulting famines could be catastrophic. "A major climatic change would force economic and social adjustments on a worldwide scale," warns a recent report by the National Academy of Sciences, "because the global patterns of food production and population that have evolved are implicitly dependent on the climate of the present century."

A survey completed last year by Dr. Murray Mitchell of the National Oceanic and Atmospheric Administration reveals a drop of half a degree in average ground temperatures in the Northern Hemisphere between 1945 and 1968. According to George Kukla of Columbia University, satellite photos indicated a sudden, large increase in Northern Hemisphere snow cover in the winter of 1971-72. And a study released last month by two NOAA scientists notes that the amount of sunshine reaching the ground in the continental U.S. diminished by 1.3 per cent between 1964 and 1972.

To the layman, the relatively small changes in temperature and sunshine can be highly misleading. Reid Bryson of the University of Wisconsin points out that the earth's average temperature during the great Ice Ages was only about 7 degrees lower than during its warmest eras—and that the present decline has taken the planet about a sixth of the way toward the Ice Age average. Others regard the cooling as a reversion to the "little ice age" conditions that brought bitter winters to much of Europe and northern America between 1600 and 1900—years when the Thames used to freeze so solidly that Londoners roasted oxen on the ice and when iceboats sailed the Hudson River almost as far south as New York City.

Just what causes the onset of major and minor ice ages remains a mystery. "Our knowledge of the mechanisms of climatic change is at least as fragmentary as our data," concedes the National Academy of Sciences report. "Not only are the basic scientific questions largely unanswered, but in many cases we do not yet know enough to pose the key questions."

Extremes: Meteorologists think that they can forecast the short-term results of the return to the norm of the last century. They begin by noting the slight drop in over-all temperature that produces large numbers of pressure centers in the upper atmosphere. These break up the smooth flow of westerly winds over temperate areas. The stagnant air produced in this way causes an increase in extremes of local weather such as droughts, floods, extended dry spells, long freezes, delayed monsoons and even local temperature increases—all of which have a direct impact on food supplies.

"The world's food-producing system," warns Dr. James D. McQuigg of NOAA's Center for Climatic and Environmental Assessment, "is much more sensitive to the weather variable than it was even five years ago." Furthermore, the growth of world population and creation of new national boundaries make it impossible for starving peoples to migrate from their devastated fields, as they did during past famines.

Climatologists are pessimistic that political leaders will take any positive action to compensate for the climatic change, or even to allay its effects. They concede that some of the more spectacular solutions proposed, such as melting the arctic ice cap by covering it with black soot or diverting arctic rivers, might create problems far greater than those they solve. But the scientists see few signs that government leaders anywhere are even prepared to take the simple measures of stockpiling food or of introducing the variables of climatic uncertainty into economic projections of future food supplies. The longer the planners delay, the more difficult will they find it to cope with climatic change once the results become grim reality.

—PETER GWYNNE with bureau reports

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Newsweek, April 28, 1975

28 April 1973: *Newsweek*'s report on the fear of a forthcoming ice age.

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Arguments and counterarguments

Fairly early on in the climate debate, sceptics developed a broad set of criticisms – many of which you still hear today – that were thrown at mainstream climate scientists and at the concept of global warming in general. Taken to the extreme, you could sum up the classic sceptical view like this:

> *The atmosphere isn't warming; and if it is, then it's due to natural variation; and even if it's not due to natural variation, then the amount of warming is insignificant; and if it becomes significant, then the benefits will outweigh the problems; and even if they don't, technology will come to the rescue; and even if it doesn't, we shouldn't wreck the economy to fix the problem when many parts of the science are uncertain.*

Probably no single sceptic would endorse the whole of that rather convoluted statement. Yet each of the points within it has been argued vigorously over the years by various contrarians. Let's look briefly at each point in turn. For a set of succinct refutations of more than 100 arguments against human-produced climate change, see www.scepticalscience.com.

"The atmosphere isn't warming" This one has been put safely to rest, although as recently as the 1990s some sceptics insisted there was no planet-wide warming at all, and the notion still crops up on the Internet. Fuelling this line of argument was the apparent lack of warming in upper-air temperatures as measured by satellites and radiosondes, but it's now clear that globally averaged upper-level temperatures are in fact warming at close to the same rate as the surface (see p.204).

"The warming is due to natural variation" This point is still argued often, even though the IPCC has concluded that the warming of the last century, especially since the 1970s, falls outside the bounds of natural variability (see p.8). In any event, the long-term ascent of global warming should outpace the peaks and valleys of natural cyclic processes such as the El Niño/Southern Oscillation or the Atlantic Multidecadal Oscillation in the long run. And variations in the Sun don't appear to explain what's been happening in the last few decades (see p.274).

"The amount of warming is insignificant" This claim mingles bona fide uncertainty about the future with a judgement call on how much warming should be labelled as significant. The genuine uncertainty is how much warming we can expect in the coming decades and centuries. As noted in "Circuits of change" (see p.249), the most widely accepted estimate for the rise in global temperature from a doubling of atmospheric carbon dioxide is about 3.0°C (5.4°F) over pre-industrial times, with a range of 2.0–4.5°C (3.6–8.1°F) deemed "likely" in the 2007 IPCC report. A number of sceptics believe that the low end of the range – if even that – is the most likely outcome, but in fact we've already warmed close to 0.8°C (1.44°F) since pre-industrial times. This puts us almost halfway to the low end of the IPCC range, and that's with carbon dioxide up only about 35% from its pre-industrial value.

"The benefits will outweigh the problems" Overall, some stimulation of plant growth does appear likely, but it's not at all certain that the benefits will be prolonged or planet-wide or that the nutritive value of crops will be sustained (see p.180). Moreover, while CO_2 may give forests a boost, the changing climate raises the risk of devastating fires and insect attacks (see p.172). Against the potential pluses of CO_2 fertilization, and other benefits such as fewer cold-related illnesses and the possibility of sailing through the Arctic in midsummer, we have to balance the various negatives, including the risk of rising seas, widespread drought and massive species loss.

"Technology will come to the rescue" This isn't scepticism about global warming so much as an affirmation of human ingenuity. Some optimists believe that geoengineering might save us from the clutches of global warming (see p.359). Even if such an approach proves feasible, it would face an uphill trek to gain funding, international approval and public confidence. Still, it's important to keep in mind the possibility and promise of technical innovation, while at the same time recognizing the reality of our present situation and the emissions trajectory we're on.

"We shouldn't wreck the economy" For sceptics motivated more by economic than scientific considerations, this is the ultimate bottom line. If we don't know with absolute confidence how much it will warm and what the local and regional impacts will be, so the reasoning goes, perhaps we're better off not committing ourselves to costly reductions in greenhouse-gas emissions. However, the eventual costs of environmental remedies have often proved much less than economic models indicated at first. Moreover, it's unclear how much further the scientific uncertainty around specific regional outcomes can be reduced. Perhaps more importantly, it would be foolish to assume that reducing emissions will cost more than coping with a changing climate – a point made emphatically by the Stern Review (see p.326). In the following chapters, we'll discuss some technologies and approaches that could actually produce net savings in the long run.

Other arguments Many critiques of climate change that emerged long ago have popped up on talk shows, blog posts and newspaper op-ed pages even after they've been debunked time and again. One example is the oft-cited argument, "If they can't predict the weather for next month, how can they predict the climate a hundred years from now?" Of course, these are two fundamentally different processes. A weather forecast tracks day-to-day changes at a given point. A climate projection looks at longer-term trends that in turn tell you about the type of weather we might expect. If you live in Germany or Minnesota and it's the first day of January, you can say with some confidence that the first day in July ought to be warmer than today, even if you can't predict whether the high will be 20°C (68°F) or 35°C (95°F).

Two other points of contention are the quality of the global models that project future warming and the data that tell us about past climate. The models certainly aren't perfect (see p.249), but they've agreed for years that we can expect a significant warming. Likewise, shortfalls do exist in the records of past weather (which weren't really designed to detect climate shifts in the first place), but they aren't enough to rule out the overwhelming evidence of change already under way. It's hard to debate a world full of melting glaciers.

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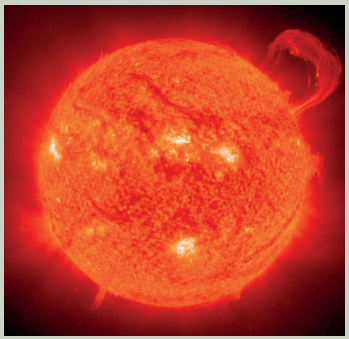
Wallace Broecker (Lamont-Doherty Earth Observatory) asked if we were "on the brink of a pronounced global warming" (and became the first research paper to use that phrase in its title). Two studies late in the 1970s by the US National Academy of Sciences confirmed that the ever-increasing levels of CO_2 in the air should lead to significant warming. Computer models were improving quickly, and they continued to indicate that warming was on the way. Finally, the atmosphere itself chimed in. By the late 1980s global temperatures had begun an ascent that hasn't abated since, except for a sharp two-year drop after 1991's eruption of **Mount Pinatubo** (see p.218) and a levelling off during much of the millennium's first decade.

The reports and findings continued to pile up through the 1980s, but with little fanfare at first outside of research labs and government hearings. Theories of global warming remained exotic enough to the public that many journalists kept the term "greenhouse effect" in quotes. The stunning discovery of the Antarctic **ozone hole** in 1985 was a turning point. Although it fostered long-lived confusion between ozone depletion and global warming (see p.32), the finding was also a new sign of the atmosphere's fragility, borne out by vivid satellite images.

The other shoe dropped in the United States during its sizzling, drought-ridden **summer of 1988**. Huge tracts of forest burned in Yellowstone National Park; parts of the Mississippi River ran dry; and on a record-hot June day in Washington DC, NASA scientist **James Hansen** delivered memorable testimony before Congress, presenting new model-based evidence and claiming to be "99% sure" that global warming was upon us, most likely induced by humans. Together, *The New York Times* and *Washington Post* ran more than forty stories on climate change in 1988 after fewer than two dozen in the preceding four years, according to Katherine McComas and James Shanahan of Cornell University. *Time* magazine named "Endangered Earth" Planet of the Year, in place of its usual Man of the Year. Even conservative politicians took note. In August, US presidential candidate George Bush (senior) declared, "Those who think we are powerless to do anything about the greenhouse effect forget about the 'White House effect'." And although the meteorological drama of 1988 was focused on North America, the political waves reverberated far and wide. In September, British prime minister Margaret Thatcher warned the Royal Society that "we have unwittingly begun a massive experiment with the system of the planet itself." As Jeremy Leggett recalls in *The Carbon War,* "1988 was the year that broke the mould." Indeed, the events of that year were enough to convince Leggett, who was then teaching at Britain's Royal School of Mines, to join Greenpeace as a science advisor to its climate campaign.

Is the Sun behind climate change?

In an attempt to let carbon dioxide – and human actions – off the hook for climate change, it's often claimed that **solar variations** account for the last century's warmth. Over the very long term, variations in Earth's orbit that shape where and when sunlight reaches the planet are the main cause of ice ages (see p.216), but this doesn't apply to our current situation. It's true that the Sun has produced more sunspots in recent decades than it did in the early 1800s. However, this mainly reflects an increase in the ultraviolet range of sunlight, which is only a tiny part of the solar spectrum. In fact, the total solar energy reaching Earth changes very little over time. Across the eleven-year solar cycle, it varies by less than 0.1%, and even across the period since the Little Ice Age chill of 1750, solar output climbed no more than about 0.12%, according to the 2007 IPCC report. Subsequent estimates by Judith Lean (Naval Research Laboratory) and others have pegged the solar contribution to twentieth-century warming at 10% or less.



Extreme ultraviolet image of the Sun showing the chromosphere, hotspots and a huge solar flare.

There's still a question mark or two when it comes to ultraviolet radiation, where the lion's share of solar variability occurs. It's possible that UV rays interact with ozone in the stratosphere to change circulation patterns, though more work is needed to clarify how this might occur. UV light also helps shield Earth from **cosmic rays** that bombard and ionize the atmosphere – a point much discussed by sceptics in recent years, thanks to work by Henrik Svensmark (Danish National Space Centre) and others. This concept got major play on UK and Australian TV in the 2007 documentary *The Great Global Warming Swindle* and in the popular book *The Chilling Stars*, co-written by Nigel Calder and Svensmark. The idea is that highly reflective low-level clouds might form more easily when tiny particles that serve as cloud nuclei are ionized, helping them to clump together more readily. Should this be true, then an active Sun would inhibit low-level clouds, thus allowing more sunlight to reach Earth and fostering warming. In lab work, Svensmark and colleagues found some evidence for the clumping effect, but it's an open question whether these particles actually make low-level clouds more prevalent in the real world. Vast numbers of potential cloud nuclei are normally present anyway, and studies comparing satellite-derived cloud patterns to cosmic-ray counts have shown conflicting results. Moreover, there's no clear evidence that more cosmic rays have actually made it into Earth's lower atmosphere over the last several decades. *The Great Global Warming Swindle* was criticized by many experts not only for downplaying these unknowns but also for using discredited data and inaccurate graphs.

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From progress to roadblocks

In the aftermath of 1988, governments began to pour money into global warming research. In 1989 the Intergovernmental Panel on Climate Change was established (see p.308) as a means of channelling research from dozens of nations and many hundreds of scientists into an internationally recognized consensus. The IPCC produced its first report in 1990, underlining the risks of global warming, and environmental activists did their best to alert journalists and the public to the problem.

By this time, the leading **environmental groups** in North America and Europe were well established, most with fifteen years under their belts. No longer a fringe movement, their cause was now part of the fabric of public life. Years of activism had helped slow the growth of nuclear power to a crawl in many countries (with no small assistance from the Chernobyl debacle in 1986). Governments and politicians had become so attuned to environmental risk that it took fewer than three years – lightning speed by diplomatic standards – from the time the ozone hole over Antarctica was discovered in 1985 to the signing of the 1987 Montreal Protocol that's now guiding the planet towards eventual ozone recovery.

For a while, it looked as if the same success might be seen with global warming. In 1992, thousands of activists joined similar numbers of journalists and diplomats in Rio de Janeiro for the United Nations-sponsored **Earth Summit**. The meeting, and the global climate treaty that emerged, kicked off years of negotiations that led to the historic **Kyoto Protocol**. (For more on Kyoto, see the following chapter.)

"Are existing environmental institutions up to the task of imagining the post-global warming world? Or do we now need a set of new institutions founded around a more expansive vision and set of values?"

Michael Shellenberger and Ted Nordhaus, *The Death of Environmentalism*

As media attention grew and as the scientific evidence strengthened, people in many countries became more aware about the risks of climate change and the possible solutions. Yet something wasn't quite clicking. Although public support for climate-change action was growing steadily, the support was "wide but shallow". In other words, people were concerned, but not sufficiently concerned to force the issue up the political agenda (nor to take personal action to reduce their own greenhouse gas emissions).

The sheer scope of the problem was one factor. Fossil fuels are used in virtually every aspect of modern society, and climate

Debates among the campaigners

Climate change is now a favoured cause of most environmental groups, but key differences in strategy and ideology remain. One question is whether to embrace or reject certain **aspects of capitalism**. With consumerism driving the world economy, some eco groups are going with the flow – encouraging people to use their spending power to make climate-healthy choices, such as buying a hybrid car or using low-energy light bulbs. Other groups, especially those with roots in 1970s counterculture, retain an abiding suspicion of the corporate world and the governments that support it, but many of these groups are working within the system to achieve results. Friends of the Earth stresses its anti-globalization work in its climate change publicity materials, yet FoE's "Big Ask" campaign played a pivotal role in securing the UK's Climate Change Act of 2008.

For environmentalists who *do* accept the idea of green commerce, the struggle to isolate genuinely "ethical" choices can be tricky. For instance, Toyota makes the world's most popular hybrid – the Prius – yet it was one of the plaintiffs in a lawsuit that aimed to block California's strict new emissions standards. Hence some groups encourage consumers to push big companies in a climate-friendly direction through shareholder actions or socially responsible investing (see p.367).

Another difference between climate activists is **how to approach fossil fuels**. Some take a pragmatic approach, figuring that oil, gas and coal aren't going away tomorrow. The US Natural Resources Defense Council has thrown its considerable weight behind "cleaner coal", on the condition that it includes CO_2 sequestration. NRDC notes the large number of coal plants already on order in China and elsewhere and stresses the need to develop cleaner technology. Other groups keep the focus on renewables. "Make no mistake: coal is dirty", says Greenpeace International, which is pushing for a global phase-out of coal as an energy source.

Looming in the background is **nuclear energy**, and the question of whether countries should turn to it to bridge the potential gap between fossil fuels and large-scale deployment of renewables. Some key environmental thinkers have lent support to the idea of using nuclear as a stop-gap, including Gaia theorist James Lovelock, *Whole Earth Catalog* founder Stewart Brand and an interdisciplinary panel of MIT scientists (see p.348). However, mainstream environmental groups remain vocally opposed to nuclear power.

A final point of difference is **picking goals**. A concrete target is the best way to motivate volunteers and supporters. The most commonly cited benchmark, consistent with the European Union's goal, is to stabilize the climate at 2°C (3.6°F) above the pre-industrial global temperature (see p.300). A more ambitious target was set by the group 350.org, which aims to bring the global concentration of carbon dioxide down to 350 parts per million. Yet global emissions would have to be cut drastically in order to meet either goal. With this in mind, some environmental groups use other types of targets as well, including legislative ones. Short-term goals are still another approach, as employed by the 10:10 campaign, which encourages individuals and organizations to aim for a 10% reduction in a year – a challenge taken up by new prime minister David Cameron for the UK's entire central government.

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Greenpeace protesting against "Dinosaur Diplomacy" at the Climate Conference in Kyoto, Japan, 1997.

change threatens to affect every country on Earth in one way or another. It's hard to motivate people to grapple with such an immense and seemingly intractable issue, and the many options for political and personal action could be too much to process. Moreover, even more than smog or acid rain, human-induced climate change is a classic "tragedy of the commons" – the benefits of burning fossil fuels accrue to individuals, companies and nations, while the costs accrue to the planet as a whole. And while the activists urged concrete action, the benefits – avoiding a global meltdown – were intangible as well.

Another difficulty for climate campaigners was the fact that global warming hit it big just when many people were getting tired of fretting about the state of the world. From its earliest days, the environmental movement had relied on stark, pseudo-apocalyptic imagery to motivate people. In her 1962 book *Silent Spring,* which set the template for environmental wake-up calls, Rachel Carson labelled pesticides and similar agents "the last and greatest danger to our civilization". In her footsteps came a series of similarly dire scenarios, from Paul Ehrlich's *The Population Bomb* to the notion of nuclear winter. Global warming lends itself especially well to this type of rhetoric. It's no exaggeration to talk about the risk of coastal settlements vanishing and the Arctic's summer ice pack disappearing. Yet when activists do hit these points, it sometimes brings to mind other predictions of environmental doomsday that didn't come to

pass (partly, of course, because society *did* respond to those earlier threats). Some observers have argued that fear-based rhetoric on climate change makes people defensive and resistant to recognizing the problem, and that it can stoke the politicization of the issue.

Even the most painless ways to reduce global warming – such as improved **energy efficiency** – came with cultural baggage in some countries. Efficiency measures had swept the US during the oil shocks of the 1970s – the top interstate speed limit was dropped to 55mph (89kph), for instance – but the practice of saving energy never lost its taint of deprivation. As oil prices plummeted in the go-go 1980s, efficiency quickly fell by the wayside and speed limits went back up. By the time global warming pushed energy efficiency back onto the national agenda, it was a loaded topic. Because so many activists had been proposing sensible energy-saving steps for years, it was easy for critics to paint them as opportunists, happy to use climate change or any other issue in order to advance their ulterior goals.

To top it all, climate activists were up against some very tricky adversaries, who were doing their best to *stop* the public from getting too worried about global warming.

Sceptics and industry fight back

Especially in the United States, a group of scientists with sceptical views about climate change – perhaps no more than several dozen – have wielded far more influence than their numbers might indicate. Until very recently, many if not most news articles about climate change included a comment from one or more of these contrarians. Their voices have been backed up in many cases by the immense money and influence of the **oil**, **coal and car industries**, largely through conservative think tanks (see overleaf). This support has enabled them to exert much sway on the US Congress, the media and, by extension, the global fight against climate change.

"I am convinced that in fifteen to twenty years, we will look back on this period of global warming hysteria as we now look back on so many other popular, and trendy, scientific ideas."

William Gray, Colorado State University, testifying before the US Congress, September 2005

Many scientist-sceptics have been portrayed as mavericks or outsiders, and with good reason. Although a few are active in climate research, many aren't. Some of the most vocal have backgrounds in subjects like solid-state physics or mathematics, sometimes with impressive résumés in their fields but little if any

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Industry lobby groups

Like their peers, the few climate sceptics active in research are employed mainly by universities and private labs. Although a few have received grants from oil and coal companies, most rely largely on public funds to carry out their work. However, that work gets an extra dose of clout, especially in the US, thanks to a number of conservative think tanks and lobby groups which cite their findings widely and use them in an attempt to convince legislators that climate change science is full of unknowns. Such centres are often influential, and many are buoyed by funding from corporations with a lot to lose from carbon restrictions.

One highly visible group throughout the 1990s was the opaquely titled **Global Climate Coalition**, which formed in 1989 as the prospect of global diplomatic action on climate change appeared on the horizon. Based at the US National Association of Manufacturers, the GCC included some of the biggest oil, car and coal companies in the world, including General Motors, Ford, BP, Shell and Exxon (aka Esso). Along with lobbying at UN meetings, the coalition angled its way into becoming an oft-quoted presence in the media. They also financed Kyoto-related commercials warning that "Americans would pay the price" for the treaty.

The GCC began to fracture with the departure of BP in 1997, Royal Dutch Shell in 1998 and Ford in 1999. By 2001, it was history, though arguably it had served its purpose and was no longer necessary. A 2001 memo written to Exxon by the US under-secretary of state, Paula Dobriansky, and later obtained by Greenpeace, states that George Bush rejected Kyoto "partly based on input from you [the GCC]". In the group's own words, "The industry voice on climate change has served its purpose by contributing to a new national approach to global warming."

Since the days of the GCC, most of the world's major oil companies have shifted towards public acknowledgement of climate change, but Exxon – the largest of them all – continued to cultivate doubt. From 2000 to 2003, according to an exposé by Chris Mooney in *Mother Jones* magazine, the company poured more than $8 million into more than forty organizations aligned with climate-change scepticism. In a rare move, the UK's Royal Society wrote to Exxon in 2006 asking it to stop funding sceptically aligned groups. In 2008, the company made a high-profile announcement that it would stop contributing to such groups, but *The Times* of London reported that Exxon gave $1.3 million in 2009 to groups affiliated with sceptical positions (albeit a smaller set of groups removed from the most heated climate-change denial).

Working largely below the media radar is Koch Industries, a Kansas-based conglomerate with major oil holdings. Its founding brothers were ranked by *Forbes* in 2010 as two of the six richest Americans. Since the Koch Industries name doesn't appear on consumer products, the firm is virtually unknown to the public. However, it gave more than twice as much as Exxon to sceptic-oriented groups from 2005 to 2008, according to a 2010 Greenpeace report that dubbed the company "a financial kingpin of climate science denial and clean energy opposition."

The global warming wing of the Washington-based **Competitive Enterprise Institute** became the leading institutional voice of climate scepticism as other entities pulled back or lost interest. Its leader, Myron Ebell, was censured by the British House of Commons "in the strongest possible terms" in 2004 after he told BBC's Radio 4 that Sir David King, the chief science advisor to prime minister Tony Blair, "knows nothing about climate science". On the release of the Al Gore documentary *An Inconvenient Truth* (see p.291), the CEI issued a pair of glossy TV advertisements that noted how fossil fuels have made life more comfortable and convenient. They ended with the tag-line "Carbon dioxide: They call it pollution. We call it life."

experience specifically in climate-change science. For example, physicist Frederick Seitz worked on atomic research in the 1940s, presided over the US National Academy of Sciences in the 1960s, and then served as a consultant to the medical research programme of the R.J. Reynolds tobacco company before becoming an outspoken climate-change sceptic. Other dissenters are trained in atmospheric science but have published few peer-reviewed papers on climate change. Many are retirees, affording them the time and freedom to act as consultants, writers and speakers without having to conduct scientific studies of their own. Of course, there have also been plenty of spokespeople for sceptical positions who aren't scientists at all (see box above), just as plenty of non-scientists speak out for climate-change action.

Right from the beginning, uncertainty has been the overriding theme in the arguments of climate-change contrarians. The core of greenhouse science – such as the consensus estimates on how much global temperature rise to expect from a doubling of CO_2 – has held firm for decades. But climate change is such a multifaceted and complicated enterprise that it's easy enough to find minor weaknesses in one study or another. Furthermore, there are always exceptions that prove the rule, such as an expanding glacier or a region that's cooled in recent decades. When contrarians point to a single event or process as a disproof of global climate change, or when advocates tout a particular heat wave as iron-clad proof that humans are meddling with climate, they're often accused of **cherry-picking**: selecting a few bits of evidence that seem to prove their point

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Bjorn Lomborg's sceptical environmentalism

Danish political scientist Bjorn Lomborg marshalled a slew of statistics and nearly 3000 footnotes to make his case that, overall, the environment is in better shape than we might think. In his influential 2001 book *The Sceptical Environmentalist*, Lomborg employed the climate-and-economy models used by the IPCC assessments to argue that major emissions reductions in the short term (*à la* Kyoto) are not only enormously costly but will have little impact on the longer-term climate outcome.

Lomborg's book got rave reviews in *The Economist*, *Rolling Stone* and elsewhere, but it was panned in other publications and pilloried by some leading scientists. The dust-up got to the point where the official Danish Committee on Scientific Dishonesty labelled Lomborg's book "objectively dishonest" (they later withdrew the finding). The magazine *Scientific American* published "Misleading Math about the Earth", an eleven-page critique of *The Sceptical Environmentalist* by four top researchers, eventually followed by a rebuttal from Lomborg himself and then a re-rebuttal from one of the four critics. Another of the four, climate scientist Stephen Schneider from Stanford University, blasted Lomborg in *Grist* magazine for "selective inattention to inconvenient literature and overemphasis of work that supports his lopsided views."

In his discussion of climate change, Lomborg glided past sea-level rise with little concern for the high-end possibilities. Moreover, Lomborg's economic focus failed to take into account the intrinsic, non-monetary value of protecting particular species and ecosystems. Even so, the book's sunny-side-up view of economic and ecological progress and its critique of environmental doom and gloom drew many fans, especially from the sceptical side of the global-warming aisle. Lomborg, in fact, ended his climate-change discussion by claiming that society has the money to control greenhouse emissions if we deemed it a high enough priority. However, he argued that many other issues – such as preventable diseases – deserve to take precedence. In his 2007 follow-up *Cool It: The Sceptical Environmentalist's Guide to Global Warming*, Lomborg staked out his turf even more firmly, remaining sanguine about such concerns as Antarctic ice (it's growing) and polar bears (their real nemesis is hunting, not warming).

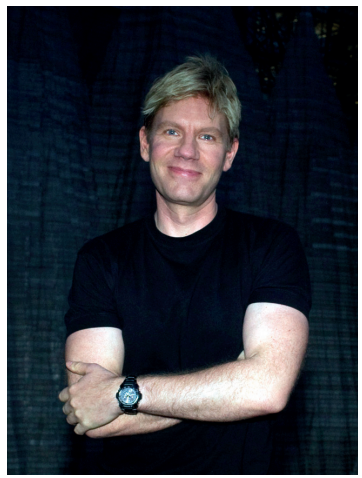
In 2010, Lomborg raised eyebrows with what seemed to be an about-face, declaring that the world should dedicate $100 billion per year to addressing climate change. That position emerged from the Copenhagen Consensus, a panel of economists organized by Lomborg. In 2004, the panel had ranked three climate measures (meeting the Kyoto Protocol goals, and assessing two types of carbon tax) at the bottom of a list of sixteen actions on which governments might best spend $50 billion to advance global welfare. But in 2009, apparently more concerned about the risks posed by global warming, Lomberg assigned a new question to the panel: given a set of potential responses to climate change, which ones would provide the best bang for the buck? Not surprisingly, taxes were the least favoured approach, whereas geoengineering and R&D investment topped the list.

while omitting counter-examples. It's a classic rhetorical technique, one well known to skilled lawyers and politicians.

Starting in the early 1990s, sceptics seized such uncertainty and exceptions and – amplified by the PR budgets of corporations heavily invested in fossil-fuel use – gave the false impression that the entire edifice of knowledge about climate change might crumble at any moment (or even that the whole thing was a colossal scam, a claim voiced more than a few times). The tactic of stressing uncertainty wasn't a new one: it had been used to delay tobacco regulation for decades and to stall environmental action in other areas, as laid out in detail by science historians Naomi Oreskes and Erik Conway in their 2010 book *Merchants of Doubt*.

Sceptic attacks have put some climate scientists directly in the line of fire. In the 1970s, the late **Stephen Schneider** studied the powerful effects of polluting aerosols and, in his book *The Genesis Strategy*, stressed the need for society to prepare for intense climate shifts. With the media focused on global cooling during this period, Schneider was often quoted, but his book emphasized the risks of greenhouse warming as well as aerosol cooling. In 1988 Schneider wrote *Global Warming*, one of the first lay-oriented books on the topic. His visibility and prolific output soon made him a prime target for critics who pointed to Schneider's earlier work on aerosol cooling, took his quotes out of context and derided his research on climate risks and assessments. Schneider later noted, "A scientist's likelihood of having her/his meaning turned on its head is pretty high – especially with highly politicized topics such as global warming."

The release of the IPCC's second assessment in 1995 drew one of the decade's sharpest rounds of sceptic vitriol. The report's beefed-up assertion that "the balance of evidence suggests a discernible human influence on global climate" was based in part on detecting climate-change **fingerprints**, the 3-D temperature patterns one would expect from the observed increase in greenhouse gases (as opposed to different patterns of warming that might be produced by other factors, such as strengthening solar input). A pro-



Bjorn Lomborg: climate sceptic?

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They're not climate scientists, but...

It's not often that a novelist gets the opportunity to speak to members of a science-oriented committee in the US Congress. The late Michael Crichton, king of the techno-thriller, got his day on Capitol Hill on 28 September 2005, not long after his novel *State of Fear* stormed the bestseller lists. Crichton, a Harvard-trained physician, was invited to discuss the role of science in environmental policymaking. He also scored a private hour-long meeting with US president George Bush, according to the 2006 book *Rebel in Chief* by Fred Barnes.

Crichton is just one of many people from outside the realm of climate research who've been anointed as experts in the field. Many of them are smart, articulate people with strong beliefs about how science should operate or how society should respond to its research. Those qualities can help give non-experts a voice in media, government hearings and the blogosphere that's well out of proportion to their actual knowledge about climate change. In a 2003 speech at Caltech entitled "Aliens Cause Global Warming", Crichton mocked the projections from global climate models, ignoring the differences between how weather and climate models work: "Nobody believes a weather prediction twelve hours ahead. Now we're asked to believe a prediction that goes out 100 years into the future". In *State of Fear*, Crichton alternated between nail-biting action sequences and tutorials in which the hero (and by extension the reader) discovers that the consensus on global warming is full of holes. It's surely the first blockbuster novel to include more than 25 actual graphs of long-term temperature trends at stations across the world. Many show cooling trends; others, such as New York, show dramatic long-term warming, presumably due to the heat-island effect. In real life, however, no climate scientist expects that every station on Earth should warm in lockstep, and urban biases have already been exhaustively studied and corrected (see p.194).

Michael Crichton

Lord Christopher Monckton

Across the Atlantic, the UK's most prominent climate sceptic may be Christopher Monckton, Third Viscount Monckton of Brenchley. Schooled in classics and journalism, Monckton has a résumé that includes serving as an advisor to Margaret Thatcher, writing and editing for several newspapers, and creating Eternity, a 209-piece puzzle that tantalized thousands of Brits and won two mathematicians a £1 million prize. Monckton later took up the cause of climate change scepticism, which dovetailed with his longstanding Euroscepticism. He addressed the US Congress in 2009 and 2010, claiming in his written 2010 testimony that "there is no consensus on how much warming a given increase in CO_2 will cause" and "today's CO_2 concentration, though perhaps the highest in 20 million years, is by no means exceptional or damaging." Nine of Monckton's assertions were contested in a rebuttal sent to Congress by more than two dozen climate scientists from NASA, NOAA, NCAR, and other labs and universities. "For those without some familiarity with climate science, his testimony may appear to have scientific validity", said the response. However, it added, "in all cases, Mr Monckton's assertions are shown to be without merit – they are based on a thorough misunderstanding of the science of climate change."

cedural delay in incorporating review and revisions to one chapter following the IPCC's plenary meeting, and confusion involving text that had been leaked to the media, led critics to accuse the IPCC – and, directly or indirectly, convening lead author Benjamin Santer (Lawrence Livermore National Laboratory) – of "doctoring the documents" and "scientific cleansing", Seitz castigated the IPCC in a widely cited *Wall Street Journal* editorial, while Santer and colleagues emphasized that the edits were a required response to review comments, per IPCC rules, and that the chapter's conclusions were virtually unchanged. Eventually, the battle subsided, but it made a lasting impact on Santer. "Nothing in my university training prepared me for what I faced in the aftermath of that report", he later said. "You are prepared as a scientist to defend your research. But I was not prepared to defend my personal integrity. I never imagined I'd have to do that."

Two sides to *every* story

In spite of the flare-up over the second IPCC report, the media had largely lost interest in global warming by the mid-1990s. According to the Cornell study cited above, the number of climate-change articles in *The New York Times* and *Washington Post* dropped from more than 70 in 1989 to fewer than 20 in 1994. In part, the drop-off was typical of how news stories come and go – alarms couldn't ring forever, at least not without some major disaster to make climate chaos seem like an imminent threat. But the sceptics and lobby groups undoubtedly played a role, having successfully convinced many journalists – and large swathes of the public – that global warming was at best an unknown quantity and at worst "ideological propaganda … a global fraud" (in the words of UK *Daily Mail* journalist Melanie Phillips).

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