

# Memorandum

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**From:** Brian Lazar, Stratus Consulting Inc.  
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**Subject:** Global Cooling White Paper

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This memorandum presents the results of a literature review and historical analysis conducted by Stratus Consulting of the scientific theory of global cooling.<sup>1</sup> We surveyed the most significant global cooling literature, and here describe the claims made by global cooling proponents, and the veracity of those claims relative to the best climate science available. This memorandum first presents an introduction on what global cooling is (Section 1). Section 2 describes the core scientific literature and personalities that posited a global cooling trend, major publications that covered the “global cooling” story in a public forum, and selected other communications that prompted the U.S. government to take action by forming a national climate program. Section 3 explores how the theory of global cooling has evolved over time and why it fell out of favor. Section 4 examines the ways in which the global cooling concept has been used in modern times as a retort to the claims of modern climate science about global warming.

## 1. Introduction

### 1.1 What is Global Cooling?

There is no officially accepted definition of “global cooling.” The term has generally been used to refer to decreases in the surface temperature of the Earth on the order of decades or longer. A single year-to-year decrease in global average temperature does not qualify as global cooling, just as a single year-to-year increase in global average temperature does not qualify as global warming. The term has also been used to refer to a scientific theory positing a longer-term (on a scale of hundreds to thousands of years) decline in global temperatures and the potential onset of a new ice age.<sup>2</sup> The term “global cooling” thus has been used to refer to discrete cooling events that may last on the order of decades, and also to cooling that lasts for the centuries or millennia of glacial periods and ice ages. Because of the variations in its use, the specific meaning of the use of the term “global cooling” in any particular reference has to be evaluated on a case-by-case basis.

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1. This task is defined as Task 3 in the current (2009) project scope of work.

2. As used colloquially, “ice age” refers to glacial periods within ice ages. This is discussed further in Section 1.2, Natural Cycles and Climate.

Between the 1940s and the 1970s global average temperatures, as measured by scientific instruments, cooled – constituting a period of global cooling. But did that mean the Earth was headed into a new ice age? Some scientists, members of the press, and decision-makers were worried about exactly that as climate studies increased in sophistication and came to prominence in the 1970s. Not only did the declining temperatures over several decades suggest a global cooling to scientists, but many of these scientists were geologists who had spent their careers puzzling over the mysteries of ice ages – why did they happen, what triggered them, and how long did they last? Some of these people jumped to the conclusion that the Earth was headed into another ice age, but most were extremely careful to nuance their claims and observations because the climate system is highly nonlinear and complex – in other words, climate is hard to understand and predict. As described in more detail below, the theory of global cooling received brief prominence in the early 1970s due to media reports, two record cold winters, consequent political attention, and the observed cooling discussed above. Most scientists, however, rejected the idea that global cooling would continue and perhaps lead to another ice age in the immediate future as scientific understanding of atmospheric chemistry and physics improved and temperatures started warming as many scientists had projected.

The difference between global cooling and global warming can be thought of in many ways, each containing important insights into the climate system. Global cooling and the descent into a new ice age is highly likely on the scale of hundreds to thousands of years. Global warming due to human activities is highly likely in the immediate future – indeed numerous scientific assessments have concluded that it is already happening. Global cooling, as popularly discussed, is largely the result of natural cycles, such as the intensity of solar radiation and decadal climate oscillations.<sup>3</sup> Global warming, as popularly discussed, is largely the result of the accumulation of greenhouse gases in the atmosphere due to human industrial activity and land use. Most importantly, the causes behind global cooling and global warming are not mutually exclusive. We examine these concepts in more detail below.

## 1.2 Natural Cycles and Climate

An ice age is a period of time when ice sheets cover part of the Earth's land surface. We currently live in an ice age as indicated by the large masses of ice on Greenland and Antarctica. Within an ice age there are glacial (i.e., cold) periods when land and sea ice cover increases, and interglacial (i.e., warm) periods when land and sea ice cover decreases. As colloquially used, an "ice age" often refers to the "glacial" period within an ice age of decreased atmospheric and oceanic temperatures. Glacial periods operate on 40,000 and 100,000 year cycles, and

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3. Humans may also cause global cooling largely as a consequence of aerosols (air pollution) that reflect sunlight and reduce the total solar input into the Earth's atmosphere.

interglacial periods last tens of thousands of years. The Earth is currently in an interglacial (i.e., warm) period, and the previous glacial maximum occurred more than 11,000 years ago.

A number of forces affect the onset of glacial and interglacial periods, including: minor changes to the Earth's orbit around the sun and the tilt of the Earth's axis (together known as Milankovitch cycles); changes in sunspot activity; the atmospheric composition of greenhouse gases; the reflectivity of the Earth's surface; large meteor impacts; volcanic eruptions; and other factors. Each of these natural forces changes the amount of incident solar radiation that is absorbed by the Earth's atmosphere and oceans by changing the distance between the Earth and the sun, by changing the amount of incident radiation that is reflected back into space, or by changing the amount of radiation that is absorbed by the Earth's atmosphere and oceans. In conjunction with feedback mechanisms, it is believed that these changes in incident solar radiation are the main drivers of glaciation. Conventional scientific wisdom (EPICA Community Members, 2004) holds that interglacial (i.e., warm) periods, such as the period in which we now live, last around 12,000 years, which would mean that we are nearing the end of the present interglacial period and may return to a glacial (i.e., cold) period of cooler, dryer climate, advancing continental ice sheets, and increased sea ice extent in the coming centuries.<sup>4</sup>

Furthermore, natural climate oscillations can also cause periods of cooler or warmer temperatures on shorter timescales. These climate oscillations are poorly understood, but seem to have phases that cause significant changes in sea surface temperatures, air temperatures, wind strength, precipitation, and other climate variables. Some of these oscillations occur on intra-decadal timescales, such as the much studied El Niño Southern Oscillation, which occurs every two to seven years, while others have inter-decadal timescales, such as the Pacific Decadal Oscillation and the North Atlantic Oscillation, which occur every 20 or 30 years.

Any of these natural phenomena, or their interactions, can lead to global cooling.

## **2. The 1970s Case for Cooling**

### **2.1 Science**

The modern study of climate began in 1957 when the International Council of Scientific Unions, a nongovernmental organization devoted to international scientific cooperation and advancement, organized an 18-month study of the Earth known as the International Geophysical Year. That same year, Roger Revelle and Hans Suess paved the way for future discussions of "climate change" in a paper challenging the widely held assumption that the Earth's oceans

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4. It should be noted that the conventional wisdom of 12,000-year interglacial periods has also been challenged, e.g., see EPICA Community Members (2004).

absorbed nearly all anthropogenic carbon dioxide (CO<sub>2</sub>). However, after the International Geophysical Year, interest in climate waned and public support for earth sciences diminished.

It took until the early 1970s for the scientific study of climate to re-emerge from the scientific backwaters. This was largely accomplished when leading scientists defined human-induced climate change as an environmental issue, thus tying it to the rise of the environmental movement in the early 1970s. For example, Carroll Wilson, an MIT management professor engaged at the science-policy interface, directed two major studies in 1970 and 1971 that garnered significant press attention, positioned climate as an environmental issue, and elevated climate as a topic of increasing discussion among scientists and policy-makers (Wilson and Matthews, 1970, 1971; Hart and Victor, 1993). Soon thereafter, a series of economically significant climatic anomalies in the early 1970s focused attention on weather and climate, providing climate research with political salience and increased government support.

However, the focus at the time tended to be on global cooling:

If the climate experts of the 1970s seem to have been a bit preoccupied with ice, that fitted their training and interests. For a century their field had concerned itself above all with ice ages. Their techniques, from pollen studies to ice core drilling, were devoted to measuring the swings between warm and glacial epochs...Now that they were beginning to turn their attention from the past to the future, the most natural meaning to attach to “climate change” was the next swing into cold (Weart, 2003, p. 80).

A conference held at Brown University in 1972 reached the alarming conclusion that another ice age may be imminent (Kukla and Matthews, 1972). The conference attendees reached this conclusion by reviewing evidence that interglacial (i.e., warm) periods tended to be short and end abruptly. They also extrapolated the Milankovitch cycles into the future and saw an imminent end to the present interglacial period in the coming centuries. Furthermore, they looked at the instrumental record, which indicted a surface temperature cooling trend since 1945. George Kukla and Robert Matthews, the conference organizers, wrote President Nixon calling for federal involvement and suggesting that the Soviets had already gained some strategic advantage by supporting climatic investigations (Reeves and Gemmill, 2004). Furthermore, the head of the National Science Foundation “seized the opportunity of the conference and the subsequent letter to the President to propose a comprehensive climate research program” (Hecht and Tirpak, 1995). The letter led the Nixon White House to form an ad hoc Panel on the Present Interglacial, which “decided that the topic was of such importance that it should go beyond simply reporting findings to including recommendations” (Reeves and Gemmill, 2004). The ad hoc committee report, released in August 1974, included the first official call for a national climate program.

Scientists in the 1960s and 1970s also began to consider the effect of aerosols – microscopic airborne particles – on climate. Scientists had suspected that volcanic eruptions altered the climate for many decades, but it was not until 1961 that J. Murray Mitchell provided convincing scientific evidence that volcanic eruptions were correlated with subsequent cooling of average air temperatures. Concern about the fallout from nuclear bomb tests, the formation of contrails from air traffic, urban smog, and government plans to build a fleet of supersonic transport airplanes all spurred additional research on aerosols. Scientists believed, and the data supported, that these aerosols caused climate cooling. This was one more alarm bell for scientists who were already studying the onset of ice ages. Well regarded scientists such as Reid Bryson, J. Murray Mitchell, and Stephen Schneider all studied the effects of aerosols on climate and came to the conclusion that aerosols were indeed cooling the climate. These scientists, however, were also well aware of the warming effect of increasing CO<sub>2</sub> concentrations. It was not until 1978 that the relative role of aerosol cooling and CO<sub>2</sub>-induced warming was sorted out (Hansen et al., 1978; Weart, 2003; Peterson et al., 2008). In the end, it was concluded that greenhouse gas warming would override aerosol cooling, not because of any one piece of information, but because of multiple independent streams of information and lines of inquiry that all led toward the same conclusion – greenhouse warming more than compensated for aerosol cooling.

## 2.2 Climate Anomalies

In the early 1970s, a series of climatological anomalies with significant impacts on U.S. economic and security interests sparked significant interest in climate by the public, government decision-makers, and the media. In 1972 and 1973 the internationally significant Peruvian anchovy harvest failed because of overfishing exacerbated by extended warm ocean currents – a climatic phenomenon known as El Niño. At the time, Peru provided 45% of the world supply of fishmeal used for fertilizer and as a feed supplement in the poultry and livestock industries (UPI, 1973). Many fishmeal consumers switched to soybeans as a substitute protein source in 1973, causing soybean prices to more than quadruple from \$3 per bushel in 1972 to \$12.90 per bushel in 1973. This contributed to a decision by President Richard Nixon to place a moratorium on U.S. grain and soybean exports (Maidenberg, 1974).

Also in 1972, drought and a severe freeze caused a 12% shortfall in the Soviet wheat harvest, along with crop failures in many other nations. The Soviets purchased approximately one-quarter of all U.S. wheat at the prevailing market price of approximately \$1.65 per bushel, but once the scale of the Russian purchases became apparent, world wheat prices increased to over \$2.50 per bushel, shocking both producers and consumers and depleting world grain reserves to dangerously low levels (Jensen, 1972). In 1974, spring floods, summer drought, and early fall frost in the American Midwest took a heavy toll on the wheat, soybean, and corn crops, further exacerbating agriculture price increases.

At the same time, an extended five-year drought in the Sahel region of Africa and a 1974 monsoon in India and parts of Southeast Asia led to a widespread humanitarian catastrophe. The crop failures of the early 1970s led many of the richer nations to compete with the least developed countries for a limited grain supply. These climate impacts on agriculture and their economic and political ramifications for developing countries concerned U.S. Central Intelligence Agency analysts, who wrote two reports citing climatic effects on agriculture as an international security issue (CIA, 1974a, 1974b). The agricultural impacts of climate anomalies had positioned climate as an issue of serious concern.

Later in that decade, it was two record-breaking winters and their impacts that drove Congress to pass climate legislation for the first time – the National Climate Program Act of 1978. The extremely cold winters of 1976–1977 and 1977–1978 personally affected many Americans as school administrators closed colleges and schools, businesses idled tens of thousands of employees, crop harvests suffered, the winter fishing and crabbing industries skipped an entire season, and heating bills skyrocketed. “The winter of 1977 was perceived by most Americans as remarkably abnormal, with severe cold in the East (coldest, in fact, since the founding of the Republic), drought in the West, and mild temperatures as far north as Alaska” (Justus and Morrison, 1988, p. 11).

### 2.3 Media

While these near-simultaneous climate anomalies (severe cold, drought, monsoon failure, and El Niño) had some direct affect on many Americans, their impact was magnified by extensive news coverage of these events. As *New York Times* science writer Andrew Revkin argues, dramatic or new developments (“pegs” on which to hang a story) draw the news media’s attention, especially on nuanced scientific issues (Revkin, 2005). According to a recent review of the scientific literature on global cooling, “A handy peg for climate stories during the 1970s was the cold weather” (Peterson et al., 2008). While far too many news stories exist to survey them all, a sample of such popular media accounts are listed below for illustrative purposes.

- ▶ A *New York Times* article from October 18, 1970 stated, “This is disturbing news for those weather experts who fear air pollution, if it continues unchecked, will seriously affect the climate and perhaps bring a new ice age” (cited in Weart, 2003, p. 82).
- ▶ Consider the titles from two *New York Times* articles written by the same author less than three months apart: “Scientists ask why world climate is changing; major cooling may be ahead” (Sullivan, 1975a) and “Warming trend seen in climate; two articles counter view that cold period is due” (Sullivan, 1975b) (articles cited in Peterson et al., 2008).

- ▶ *Science Digest's* 1973 article "Brace yourself for another Ice Age" stated "the present episode of amiable climate is coming to an end, and an Ice Age could be just centuries away" (Colligan, 1973).
- ▶ *Time Magazine's* (1974) article "Another Ice Age?" ominously worried that "when meteorologists take an average of temperatures around the globe they find that the atmosphere has been growing gradually cooler for the past three decades... Climatological Cassandras are becoming increasingly apprehensive, for the weather aberrations they are studying may be the harbinger of another ice age."
- ▶ *Newsweek's* (1975) article "The Cooling World" stated that "The central fact is that after three quarters of a century of extraordinarily mild conditions, the Earth's climate seems to be cooling down" (Gwynne, 1975).
- ▶ In addition to the news, books were published during this time making similarly dire statements. From *The Weather Conspiracy: The Coming of the New Ice Age*: "Many climatologists believe that since the sixties the world has been slipping toward a new ice age. The only questions in their minds are: What kind of ice age will it be, little or great? How soon will it happen?" (Impact Team, 1977).

### 3. Cooling Falls out of Favor

In the late 1970s scientific opinion began to shift away from cooling theories. As scientists studied aerosols, they realized that they do not cool uniformly. For example, further study showed that the smoke and soot that enters the atmosphere from large-scale forest clearing and burning absorbs radiation from the sun, consequently leading to a warming effect. Moreover, rain events wash aerosols out of the atmosphere in a matter of weeks, compared to CO<sub>2</sub> – the main global warming culprit – which has an effective lifetime in the atmosphere of around 100 years, suggesting a stronger warming effect simply due to accumulation over time.<sup>5</sup> Researchers began to study cooling from volcanic eruptions and the length of time it took for temperatures to rebound, and they extrapolated the results to man-made aerosol cooling trends. Their results showed that global warming dominated over the calculated cooling trends. Scientists also began to run rudimentary computer models of the atmosphere to predict CO<sub>2</sub>-induced warming compared to aerosol cooling, and again global warming dominated in the models. Most importantly, the observed cooling trend between the 1940s and the 1970s came to an abrupt end and temperatures started to increase (Weart, 2003; Peterson et al., 2008). Multiple independent streams of information all pointed toward greenhouse gas warming as the dominant

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5. A recent study has indicated that the warming effect from CO<sub>2</sub> may be largely irreversible for 1,000 years after emissions stop (Solomon et al., 2009).

effect of man's activities on climate, rather than those factors that were hypothesized to contribute to global cooling.

Global warming skeptics consistently claim that the 1970s were a period of general scientific consensus that the world was cooling. These claims of scientific consensus on global cooling come from people as varied as U.S. Senator James Inhofe (2003), Michael Crichton (2004), Pat Michaels (2004), and many others. However, a recent survey by Peterson et al. (2008) of the scientific literature of the time indicates that no such consensus existed. This study surveyed scientific articles on global cooling and global warming from the time period 1965–1979. “The survey identified only 7 articles indicating cooling compared to 44 indicating warming. Those seven cooling articles garnered just 12% of the citations” (Peterson et al., 2008). In other words, the evidence indicates that no scientific consensus on cooling existed during this time; global cooling simply received prominent media attention.

Nevertheless, even while global average temperatures increase, some regions or localities may experience more pronounced warming, temperature declines, or no temperature change at all. For example, while North America as a whole warmed between 1955 and 2005, Alaska and the continental interior have warmed much more than the southeastern United States (Field et al., 2007). Global climate oscillations such as the Pacific Decadal Oscillation or the North Atlantic Oscillation, proximity to the coasts, or other climatological or geographical variables may cause periods of relatively cooler temperatures in certain regions even as the globe as a whole warms.

#### **4. Global Cooling Enters the Global Warming Debate**

Many people have used the scientific theories and media reports of global cooling from the 1970s as an argument against the current scientific consensus on global warming. Most of these arguments present the complex process of scientific discovery as a swing from advocating global cooling to advocating global warming, typically due to ignorance or self interest. Scientists posit hypotheses, empirically test those hypotheses, and reject, revise, or accept those hypotheses as empirical evidence dictates. Some of the major global cooling arguments used against global warming are presented below along with a response.

- ▶ **Argument 1:** Global warming is just the current fad in a journalistic seesaw between global warming and global cooling (e.g., Anderson and Gainor, 2006; Will, 2008).
  - Journalists have covered both global warming and global cooling, but the highest quality journalistic coverage never took advocacy positions and simply stated the facts of observed weather and/or current scientific thought. Many of the articles cited by global cooling advocates as “advocating” one position or another were

actually quite careful in their statements to indicate that they were covering an uncertain topic on which scientists disagreed (Peterson et al., 2008).

- Ultimately, however, conflating news coverage – especially the headlines attached to stories – with the evolving scientific understanding of climate misses the point entirely. Even if news coverage is biased or sensational, that does not mean that scientists are biased or sensational. For an accurate understanding of the state of climate science, one needs to look beyond the news media at the science itself.
- ▶ **Argument 2:** There is no agreement within the scientific community on global warming or its human causes; consequently the entire global warming debate is based on speculation, not evidence (e.g., Crichton, 2005; Behreandt, 2007, 2008).
  - In fact, many respected scientific bodies have said just the opposite – that human activities are altering the atmosphere and this is leading to warming temperatures. These scientific bodies include the Intergovernmental Panel on Climate Change (IPCC, 2007a), the National Academy of Sciences (NAS, 2001), the American Meteorological Society (AMS, 2003), the American Geophysical Union (AGU, 2003), the American Association for the Advancement of Science (AAAS, 2006), along with many other national and international scientific bodies.
  - One researcher analyzed 928 abstracts from peer-reviewed scientific publications between 1993 and 2003 with the keywords “global climate change.” Of the 928 articles analyzed, 75% explicitly or implicitly accepted global warming, 25% dealt with methods or paleoclimate (e.g., studies of the last ice age), and **none** of the papers disagreed that global warming is occurring (Oreskes, 2004; Pielke and Oreskes, 2005). This demonstrates the strong scientific consensus, based on evidence, that global warming is real. Because peer reviewed publications typically have strong, evidence-based criteria for publication, speculation rarely makes it into the peer reviewed literature.
  - Another pair of researchers tackled the question of scientific consensus using a different method. These researchers surveyed 3,146 earth scientists, including some with “well-documented dissenting opinions on global warming theory” (Doran and Zimmerman, 2009). According to the results of this survey, 90% of respondents believed that temperatures had risen, and some 82% believed human activity was a significant contributing factor. These researchers concluded, “It seems that the debate on the authenticity of global warming and the role played by human activity is largely nonexistent among those who understand the nuances and scientific basis of long-term climate processes” (Doran and Zimmerman, 2009). While an opinion survey could be construed as just another forum for

speculative opinions, it is notable that the people who understand the most about the climate system have a high degree of confidence that temperatures have risen and that human activity is a major contributor. Consider Governor Arnold Schwarzenegger's perspective on the potential danger of global warming: "It is like when my child is sick and has a huge fever, and I go to 100 doctors, and 98 doctors says this child needs immediate medical care, and 2 say no, forget it, go home and just relax, I go with the 98. It's as simple as that" (Schwarzenegger, 2007).

- Doran and Zimmerman sum the case up succinctly: "The challenge, rather, appears to be how to effectively communicate this fact [of general scientific consensus] to policy makers and to a public that continues to mistakenly perceive debate among scientists" (ibid).
  - Finally, it is worth emphasizing that the scientific consensus on global warming is based on thousands of rigorous, evidence-based peer reviewed studies over several decades. For example, the Intergovernmental Panel on Climate Change publishes technical reports on climate change about every six years. As evidence has accumulated through scientific study that human activities are affecting the climate, this well-respected body of expert scientists has increased its reported confidence in its conclusions (see IPCC, 1990, 1995, 2001, 2007b).
- ▶ **Argument 3:** Any rise in temperature is entirely due to variations in solar output or natural climate variability such as the North Atlantic Oscillation. These trends also indicate imminent global cooling (e.g., Jacoby, 2008; Robinson, 2008).
- While solar variability does affect climate, the bulk of 20th century observed temperature changes are adequately explained by greenhouse gases, volcanic eruptions, and aerosols – with a small contribution from solar variability. There is no reason to expect the physics and chemistry that have driven the climate system during the 20th century to suddenly and inexplicable change (Duffy et al., 2009).
  - However, natural climate cooling and human-induced global warming are not mutually exclusive. Solar output has a substantial effect on climate as do planetary climate oscillations such as the El Niño Southern Oscillation and the North Atlantic Oscillation. These natural cycles add layers of complexity to, rather than replace, the effects of increases in greenhouse gases. Global warming can mean less cooling during periods of decreased solar output or during a cool phase of the North Atlantic Oscillation. Alternatively, global warming can mean greater warming during periods of increased solar output or during a warm phase of the North Atlantic Oscillation.

- Natural climate variability has a major effect on current climate and may even cause the climate to cool while greenhouse gas concentrations continue to increase. However, an observed cooling does not mean that greenhouse gas warming poses no threat. The essential point here is that drawing simple conclusions from a system as complex as the climate is difficult. Any statement about climate entrains significant uncertainty, and such uncertainty needs to be communicated effectively for scientists, decision-makers, and the public to make informed judgments about the relative confidence we have in projections of future climate. While a broad base of evidence indicates that the globe has warmed over the last several decades and a broad scientific consensus indicates a high likelihood of future warming, significant uncertainty accompanies projections of the magnitude of future climate change, which involves complex phenomenon that prevent precise forecasting.

## 5. Conclusions

Global cooling refers to a theory that the earth is on the verge of another ice age. This theory emerged in the 1970s primarily from research studying past ice ages, combined with observations of temperature cooling over the previous decades and fears that atmospheric pollution might trigger a new ice age. At that time, the study of climate change as a result of greenhouse gas emissions was in its infancy, and not yet sufficiently developed to provide reliable scientific projections of the relative effects of greenhouse gas emissions and aerosols on the earth's climate. Climate research has since advanced considerably, and scientists now recognize that global warming due to greenhouse gas emissions dominates the factors that contribute to cooling. Despite the broad scientific consensus and evidence accumulated over the past three decades, global warming skeptics continue to point to the 1970s global cooling theory as alleged proof that scientists have no idea how climate will change and the entire global warming debate is overblown. However, the main claims of global warming skeptics regarding global cooling are either irrelevant, oversimplified, or patently false. Global warming is a widely accepted scientific theory supported by multiple independent streams of information.

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