Ozone Depletion

FABRICATING A HOLE IN THE SCIENTIFIC EVIDENCE

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This story highlights three tactics of science misinformation and disinformation efforts: deviant criteria of assent, cherry-picking, and neglect of refuting information. See our website article Features of Science Misinformation/ Disinformation Efforts for more information regarding these tactics.

"Melanoma and skin cancer can happen to anyone, anywhere and whatever age," - Jennifer Nicholson

Jennifer Nicholson ensured that her daughters Freja and Lily used sunscreen whenever they left their home in Leeds, England for beach vacations. However, Freja was less diligent as she grew older, and she even occasionally used tanning beds. In 2014, a once inconspicuous mole on Freja's back became dark and lumpy. A biopsy revealed that the mole was benign, but two years after it was removed, Freja discovered a lump in her armpit. In February 2016, a biopsy revealed that 17-year-old Freja had melanoma—the deadliest form of skin cancer that results from uncontrolled division of melanocytes (Holohan, 2016). Three of the fifteen lymph nodes Freja had removed tested positive for cancer. Even after excising the malignant nodes, Freja continued to suffer from nausea and severe headaches. More tumors soon developed on her arm, breast, and brain.

Though Freja attempted to maintain some semblance of normalcy, such as applying to college to pursue a degree in geology, her condition continued to deteriorate. The teen eventually became so sick that she informed her mother that she wanted to die. Freja passed away on November 9th, just eight months after her diagnosis (Holohan, 2016). Freja is just one example of the increasing number of young people receiving diagnoses of malignant melanoma. Though skin cancer is not always caused by ultraviolet (UV) radiation, even minimal sun and indoor tanning bed exposure increases the risk of developing both carcinomas and melanomas by up to 59% (Lazovich et. al., 2010). A major environmental threat discovered in the 1970s has given us insight as to why cases such as Freja's have become increasingly common.

Advancements in Science and Industry

Walter Noel Hartley first proposed the existence of stratospheric ozone in 1881 to explain why 220-320nm wavelengths of light from the Sun did not reach Earth's surface. Three decades later, Fabry and Buisson's (1912) solar spectrum analysis revealed that an atmospheric gas, ozone (O_3), absorbs part of the Sun's radiation. Later, ozone was identified as specifically protecting the Earth from some UVB and all UVC, the most threatening types of UV radiation that causes sunburns, damages DNA, and increases a person's risk of skin cancer. As technology advanced throughout the early 20th century, scientists determined that the amount of ozone in the atmosphere varied by location and time of year (Dobson & Harrison, 1926). The International Ozone Commission was formed in 1948 to encourage collaboration between scientists investigating the ozone and increase the number and locations of ozone-level observations (Christie, 2001).

During this period, technology advanced rapidly, resulting in cars, refrigerators, microwaves, airplanes, and air-conditioning systems gained widespread use among citizens of developed nations. Mass manufacturing of these modern conveniences required constant production of industrial chemicals for an array of functions and led to a number of breakthroughs in the field of chemistry. For example, while attempting to develop a cheaper and non-toxic refrigerant, the chemist Thomas Midgley Jr. (see: *Leaded Gasoline: Poison Everywhere* for the story of Midgley's role in developing leaded gasoline) determined that chlorofluorocarbons (CFCs) worked well for such a purpose (Midgley & Henne, 1930). CFCs quickly became one of the most widely used chemicals for refrigeration, aerosol propellants, and air conditioning. DuPont gained substantial revenue from one such CFC product—a refrigerant that would come to be called Freon (Figure 1). The low boiling point and relatively minimal cost of CFCs made them essential for electrical cooling.

Ozone protects the earth from UVB and UVC rays by absorbing some of the light as it passes through the atmosphere. In doing so, the O_3 molecule breaks apart into a single oxygen atom and an O_2 molecule. That single oxygen atom then combines with atmospheric O_2, thereby creating more O_3, and allowing the atmosphere to continuously replenish the ozone layer. In the early 1970s, Mario Molina and Sherwood Rowland from the University of California, Irvine used scientific modeling to show that CFCs, containing highly electronegative halogen atoms could potentially affect ozone. In 1974, they published a paper that described how chlorine atoms from CFCs might remain in the stratosphere for long periods of time and could accelerate the decomposition of ozone into O_2 molecules faster than the ozone could replenish (Molina & Rowland, 1974). Their work supported the notion that CFCs could cause ozone depletion, leading to lower concentrations of the UV blocking molecules.

Figure 1. An example of a social media post from a resident of Ida Grove in January 2019.

Although the UV protection provided by ozone had been well-established, little was understood about how much damage CFCs had already caused to Earth's atmosphere and what risks increased UV exposure could pose to humans. Medical scientists in the early 20th century had already confirmed through human and animal investigations that sun exposure was undoubtedly linked to skin cancer (De Gruijl, 1999). Ozone depletion was therefore not just a scientific issue, but also a matter of global public health. Such concerns led leaders from around the world to discuss CFC use and regulation. More research was urged regarding the ozone layer (Christie, 2001), and in 1975, the National Academy of Sciences (NAS) was tasked with studying the issue and preparing several reports over the next decades to develop a better understanding of what human-caused ozone damage could mean for life on Earth (Mullin, 2002).

QUESTION 1
Scientific modeling that makes projections (e.g., weather, climate, disease spread) use well-established information along with justifiable assumptions. How do these assumptions make modeling susceptible to misinformation/disinformation efforts?

Societal and Corporate Reaction

Note how Rowland and Molina's study had immediate implications for financial stakeholders despite lacking direct empirical evidence. Scientists often use modeling to investigate phenomena under specific conditions. Modeling is useful in many ways including investigating phenomena not amendable to direct investigation, and projecting future trends.The news of potential ozone depletion due to CFCs was concerning to the public and a bombshell for financial stakeholders in the refrigerant and aerosol industry. At the time, no feasible alternatives to CFCs were in development. Thus, any potential regulatory policy was predicted to have a massive economic impact (Mullin, 2002; Hobson, 2010). Concern existed that the cost of basic goods such as refrigerators and cars would skyrocket, potentially making them inaccessible for most U.S. citizens (Mullin, 2002). Further, corporations that bought and used CFCs feared that they might have to drastically raise prices and rely upon foreign produced CFCs. DuPont, one of the world's leading producers of aerosols and CFCs, was at risk of losing substantial sales and profits to global competitors if domestic

Image 1 from https://www.ebay.com/motors/blog/what-to-do-about-r12-refrigerant-the-original-freon/

regulations were enacted (Smith, 1998).

NATURE OF SCIENCE CONNECTIONS

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Shortly after Rowland and Molina's 1974 publication, the DuPont chairman pledged during a congressional hearing, "if credible scientific data … show that any chlorofluorocarbons cannot be used without a threat to health, DuPont will stop production of these compounds." (Smith, 1998, p. 559). However, the human health impacts of ozone depletion had yet to be fully investigated, meaning that DuPont had years before they would be called upon to fulfill their promise (Christie, 2002). Nonetheless, the pledge supported DuPont's public image of being "scientifically-driven." Producers and users of CFCs around the world would not accept Rowland and Molina's ideas at face value. In 1980, DuPont and other companies formed the "Alliance for Responsible CFC Policy", a lobbying group that sought to cast doubt about the certainty of CFC science, and fight regulation of ozone-depleting compounds.

Along with other CFC producers in the Chemical Manufacturers Association, DuPont contributed millions of dollars towards a multi-year research program to privately gather evidence regarding ozone depletion to address some of the questions that arose from Rowland and Molina's work (Maxwell & Briscoe, 1997). DuPont also began negotiations with policymakers and regulatory institutions to delay any regulatory policies that would limit CFCs until "scientific uncertainties could be resolved" (Maxwell & Briscoe, 1997). Finally, the company began to invest several million dollars per year into research for less harmful alternatives to CFCs (Smith, 1998). DuPont's underlying strategy was to delay any CFC regulation until the company could develop and commercialize their own alternative. DuPont resisted specific policies that directly impacted their CFC business while simultaneously publicly supporting and assisting in the development of environmental legislation. Such opposition to regulatory policies was not unique to the United States, as CFC industries in Europe and Japan also resisted government intervention (Morrisette, 1989).

QUESTION 1

Disinformation/misinformation tactics often focus on scientific uncertainty What are the pros and cons of waiting for scientific certainty in socio-scientific decision-making?

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Deviant criteria of assent

Carefully considering the credibility and nature of scientific evidence is an important part of making policy decisions. However, notice how Dupont demands evidence on only the human health impacts of ozone depletion before agreeing to any CFC regulation policy. This is an example of a party putting forth a deviant criterion of assent; where a group refuses to accept a scientific claim until their unreasonable demands are met. Skin cancer and other human health impacts of UV radiation often manifest much later in life. Thus, it would be decades before such data could be gathered and analyzed. Not only did Dupont's efforts work to delay CFC policy, but it drew attention away from other potential impacts of ozone depletion such as climate change and damage to marine life (Liftin, 1994 [16], pg. 64). Also notice the choice of the word "credible" in their pledge. This qualification is a subtle hint at DuPont's future efforts to discredit and dismiss reputable scientific evidence against CFCs.

While DuPont argued that ozone depletion science lacked sufficient support to warrant regulation, public opinion had already begun to shift the market away from aerosol use (Maxwell & Briscoe, 1997). Large consumer product companies such as Johnson Wax began making highly publicized marketing campaigns to phase out aerosol use—a move that greatly threatened DuPont's CFC business. Public opinion favored a precautionary approach as consumers became wary of aerosol products altogether (Smith, 1998). Despite attempts to delay regulation, the U.S. banned of all non-essential aerosol use in

1978 resulting in an immediate one-third reduction in DuPont's CFC sales (Smith, 1998).

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Deviant criteria of assent

The claim that no "real" evidence existed for CFC-caused ozone depletion is another example of deviant criteria of assent. Science misinformation/ disinformation efforts often make unreasonable demands of the scientific community in an effort to deny the credibility of its conclusions. DuPont sought to discredit the science claiming the early CFC warnings were based on scientific models rather than direct empirical evidence. Modeling is one of several credible and often-used methodological approaches in science, and is based on both empirical evidence and logical assumptions.

Concern about the ozone peaked in 1979, when the NAS released a report predicting a 16% depletion in ozone levels if CFC pollution continued at the current rate (NAS, 1979). Following the report, the EPA proposed to extend regulating CFCs beyond aerosols to other uses such as refrigerants (Maxwell & Briscoe, 1997). DuPont, still seeking a viable alternative to CFCs, responded to the shifting public and policy sentiment and growing scientific evidence by presenting alternative claims that that no actual evidence of ozone depletion had been detected and that all the current figures were computer projections based on "uncertain assumptions" (Rowlands, 1995, p.50). Rowland and Molina countered DuPont's claim by asserting that scientists didn't need to detect depletion for the science to be validated—they just needed accurate measurements of chlorine radicals in the stratosphere. By then, however, the damage could be irreversible (Mullin, 2002).

Despite the dire warnings of scientists and outspoken concern from environmental groups, CFC regulation slowed significantly over the next five years (Mullin, 2002). In 1980, the newly-elected U.S. president and Congress were much less favorable towards increasing business restrictions than the previous administration. Additionally, NAS reports repeatedly adjusted the predictions of ozone depletion downward, going as low as 2-4% depletion in 1984 (NAS, 1984). DuPont and other major CFC producers took advantage of these changing projections and formed the Alliance for Responsible CFC Policy to prevent further regulatory action on CFCs (Maxwell & Briscoe, 1997). The Alliance was founded "to ensure that government did not regulate based on unproven and unverified theory" (Mullin, 2002). Much of the alliance's efforts went towards lobbying against further CFC policy and stonewalling legislation. DuPont also pulled back on its efforts to develop CFC alternatives. When asked about the company's decision, Joe Steed, DuPont's environmental manager stated, "There wasn't scientific or economic justification to proceed. How do you trade a possible [environmental] risk for a [business] risk that is real?" (Liftin, 1994, p.70). However, Rowland and Molina's idea had significant support within the scientific community by this point (Hobson, 2010). The question was not whether CFCs were damaging the atmosphere, but how much damage had already been done. Unbeknownst to researchers, they would not have to wait long for an answer to that question.

The Ozone Hole and Public Outcry

In 1985, British scientist Joseph Farman and his colleagues published the first report of a dramatic loss of ozone above the south pole, later to be named the "ozone hole" (Farman et al., 1985). The ozone hole is a seasonal phenomenon during which ozone levels drop dramatically in a concentrated area over the south pole. This typically occurs during the Antarctic winter and early springtime due to the low temperatures and lack of atmospheric circulation. Most of the depletion takes place within the polar vortex where air moves in a circle around the south pole, trapping the stratosphere in a concentrated area. Each spring, over 50% of the ozone present in this area is destroyed by the chlorine from CFCs (Sparling, 2001). At first, the British researchers only had numerical data to show that the ozone levels around the south pole had dramatically decreased. However, in 1985, NASA scientist Pawan Bhartia presented one of the first satellite images of the ozone hole (See Figure 2) at an international conference.

The presence of the hole and accompanying images of it rattled both policymakers and the public (Mullin, 2002). Rarely had an environmental phenomenon been as visceral as the images released of the ozone hole. Scientific debate quickly turned to determining the extent to which the ozone hole was caused by

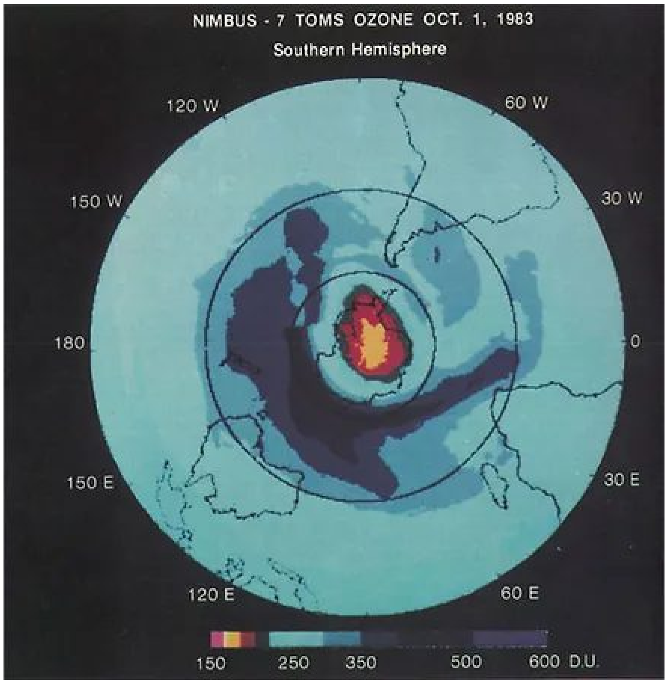

Figure 2. October 1, 1983 image of the Antarctic Ozone Hole shown by Bhartia at the IAGA/IAMAP meeting in Prague, Czechoslovakia

CFC pollution versus being just a natural phenomenon. Media outlets exploded with the groundbreaking discovery and called on policymakers to devise a plan. Despite the location of the hole occurring for only two months over a remote part of Antarctica, people were scared by the prospect of increased risks of cancer or blindness from excess UV exposure (Hansen, 2012). Compounding public unease was the fact that more evidence continued to surface over the following years that supported the notion that Rowland and Molina may have actually underestimated the magnitude of ozone damage (Mullins, 2002). A 1986 report stated that CFC levels in the atmosphere had effectively doubled since 1973 (Hobson, 2010). The U.S. Environmental Protection Agency (EPA) also began gathering projections of what ozone depletion could mean for human health and other species' lives.

Chemical companies like Dow and DuPont also responded to the scientific advances. DuPont quickly shifted its position once again to accommodate public opinion and avoid potential lawsuits as the prospect of connecting ozone depletion to real incidences of cancer began to increase (Mullin, 2002). Additionally, the chemical company wanted to protect its public image of being a scientifically-driven organization and could see that political decisions were going to favor CFC regulation—a fact which DuPont realized still provided them with opportunities to exert their influence on the issue (Rowlands, 1995, p.110).

The Montreal Protocol

The Montreal Protocol is an international treaty written by the United Nations that called for the slow phase out of CFC production across the world (Montreal Protocol, 1987). Though the protocol was in negotiation before the identification of the ozone hole, there was still uncertainty regarding the economic consequences of implementing a ban without a viable alternative. Legal action to ban CFCs was therefore delayed until the chemical industry began cooperating with legislators and policymakers. DuPont's switch in position, for example, resulted in them once again ramping up their efforts to develop a viable CFC alternative. Industry executives claimed that a longer timeline for the CFC ban would enable the development of a suitable alternative and would therefore be less of a strain on the economy—a compelling argument to many politicians. Though the EPA originally sought a complete phaseout of CFCs within 10 years, DuPont ultimately agreed to a 50% phaseout by 2000 with a complete phaseout occurring over the following decades (Maxwell & Briscoe, 1997). Through these negotiations, chemical companies, were able to heavily influence policy deliberations that ultimately led to the signing of the Montreal Protocol.

DuPont's efforts to stonewall legislation regarding CFC production and reluctance to reduce and eliminate their own CFC production meant that CFC-caused ozone depletion continued well into the early 1990s. According to the EPA, the ozone depletion that had already occurred would result in an additional 200,000 skin cancer deaths in the U.S. alone (Doyle, 1991). Despite the delay, however, international commitments to ending emissions of ozone depleting substances have been incredibly successful. Without government intervention, CFC pollution would have had devasting consequences for the environment and human health. If CFC pollution had continued increasing at the rate observed in the 1980s, the ozone above the United States might have already depleted by up to 50% by

Image 1 from https://www.meteo.be/uploads/media/5fe099835fb9a/first-ozone-hole-picture.jpg now (Hansen, 2012). By 2065, harmful UV radiation could have increased by 200% in higher latitudes (Mckenzie et. al., 2011). The EPA estimates that the full implementation of the amended Montreal Protocol on Substances that Deplete the Ozone Layer will reduce U.S. cases of skin cancer by 443 million, save 2.3 million American lives, and prevent 63 million cases of cataracts for Americans born between 1890-2100 (US Environmental Protection Agency, 2020). Baldwin and Lenton (2020) summarized the results of the Montreal Protocol and resultant legislation by stating, “Halting and reversing damage to the ozone layer is one of humanity's greatest environmental success stories” (p.1).

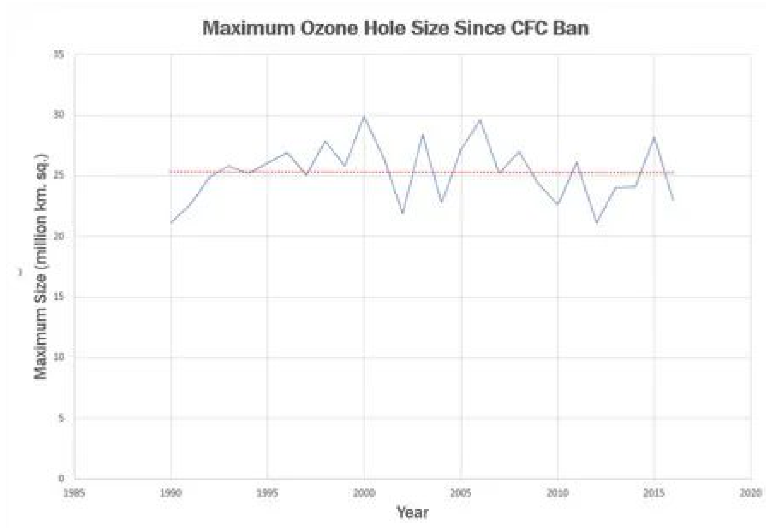

Figure 3: Size of Ozone Hole size from 1990 to 2015 “Twenty-five years since the ozone hole killed us all” (Heller, 2017)

Continued Efforts to Sow Doubt

Despite the overwhelming evidence that human emissions were depleting the ozone, some groups continued to spread doubt about ozone depletion long after passage of the Montreal Protocol. By the late 1980s, “anti-environmentalists” opposed the CFC bans, and some claimed that ozone depletion had been overstated (Cheevers, 1994). Since then, numerous groups have continued to claim that the issue of ozone depletion has been dramatized by the media and even scientists themselves (e.g., Lieberman, 2007; Shewchuk, 2019). Arguments that ozone depletion was “overhyped” often rely on the pseudoscientific claim that the ozone hole is a naturally recurring phenomenon that was not influenced by human interference with the atmosphere (Lieberman, 2007; Heller, 2017; O'Sullivan, 2018).

One way such disinformation is spread and appears compelling to a uniformed public is through cherry-picking of data that purposely leaves out refuting information. For example, an article titled “Twenty-five years since the ozone hole killed us all” appearing at realclimatescience.com provides the graph appearing in Figure 3 showing the maximum size of the ozone hole after the signing of the Montreal Protocol in late 1987. The graph cherry-picks the data to wrongly support the claim that the ozone hole was not caused by CFCs.

While appearing to support the notion that CFC reduction had no impact on the size of the ozone hole, the impact of the CFC ban on the ozone hole is readily apparent when data from 1978 forward are included (see Figure 4). The ozone hole size has stabilized since shortly after the Montreal Protocol agreement, but CFCs and HCFCs tend to stay in the atmosphere for years after being released, which means that undoing damage to the ozone will take some time to occur. Recent NASA studies show that the ozone hole depletion over Antarctica is 20% less than it was in 2005 (Reiny, 2018).

Figure 4: Size of Ozone Hole size from 1978 forward.

Figure 3 image from https://realclimatescience.com/wp-content/uploads/2017/07/Image1689_shadow.png
Figure 4 image from https://ozonewatch.gsfc.nasa.gov/statistics/ytd_data.txt

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Cherry-picking

Figure 3 shows a graph where the authors excluded data that was contrary to their claim. This is an example of cherry-picking – a common tactic in science disinformation efforts. Cherry-picking is not the same as putting forth the best representative data when publishing or presenting research. The latter is done to help reduce complexity while cherry-picking is a misrepresentation of the overarching data and conclusions.

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Scientists must make sense of data, and this entails interpretive judgments, because data do not tell scientists what to think. Over time, the wider scientific community will decide to what extent an individual scientist’s decisions hold up to scrutiny, and this significantly reduces, subjectivity in science.

Neglect of refuting information and cherry-picking are two characteristics of science misinformation/ disinformation. In authentic science research, scientists analyze extensive data and must assess what is meaningful and what is likely erroneous or an outlier.

QUESTION 1

How is that different than neglecting refuting information or cherry-picking?

QUESTION 2

Within science, how does the diverse world-wide community of scientists along with the peer review vetting process maintain the integrity of research judgments and avoid cherry-picking of data and neglecting refuting information?

Ozone Depletion and Human Health

Individual cases such as Freja's cannot be definitively tied to ozone depletion, but studies have linked it to large increases in skin cancers. Issues involving science and society are often complex, having economic, ethical, and life-changing dimensions that require careful consideration. Those difficulties are magnified when misinformation/ disinformation is introduced. Citizens are hardly in a position to judge the science, but they can learn to set aside their biases and ideologies to spot the characteristics of science misinformation/ disinformation efforts.

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