GEOFFREY KABAT

Who's Afraid of Roundup?

In the age of "Facebook science," the weight of evidence must compete with powerful popular narratives. Can common sense help?

In May 2019, a California jury awarded $2 billion to a husband and wife who claimed that the weed-killer Roundup caused their non-Hodgkin's lymphoma. The defendant in the suit was Bayer AG, which had recently acquired Monsanto, Roundup's manufacturer.

Crucial in determining the judgment was Alameda County Superior Court judge Winifred Smith's denial of a request by Bayer's lawyers to share with the jury the US Environmental Protection Agency's recent determination that the active ingredient in Roundup, glyphosate, is not carcinogenic and poses no risk to public health when used as directed. "What is the relevance?" the judge is reported to have asked.

Instead, the judge allowed the plaintiffs' lawyers to base their case on the International Agency for Research on Cancer's (IARC) 2015 determination that glyphosate is a "probable carcinogen." Deprived of the opportunity to hear any countervailing evidence, the jury found for the plaintiffs.

This was the third Roundup trial, following other cases in which a total of $158 million was awarded to the plaintiffs. At present there are over 18,000 lawsuits pending against Bayer in the United States based on claims that exposure to Roundup was responsible for the plaintiffs' cancers.

The stakes are not limited to Bayer and those involved in the lawsuits. They extend to farmers, the agricultural sector of every country, and consumers worldwide who depend on affordable food. And even beyond these impacts, what is at stake is society's ability to rely on the best scientific evidence on questions that are entangled with competing interests and deeply held worldviews.

Roundup, the world's most widely used herbicide, has been in use for 45 years. By targeting a key enzyme present in all plants, it can kill a wide variety of weeds. Farmers value it because it enables them to manage weeds more easily and more effectively than other products, and because it reduces the need for tillage, thus improving soil conservation. Roundup also has low toxicity compared with products it has replaced, such as atrazine and alachlor (both of which are banned in Europe). A successful campaign to ban Roundup would result in a worsening of soil quality and deny farmers a crucial tool for controlling weeds, confronting them with the choice between a return to using more harmful herbicides or experiencing major reductions in agricultural productivity for many crops.

The sole dissenting voice

In view of the prominence given IARC in the legal proceedings, it is noteworthy that the agency stands alone in its conclusion that glyphosate poses a carcinogenic risk. The US Environmental Protection Agency's recent assessment is only the latest in a succession of reports from national regulatory agencies, as well as international bodies, that support the safety of glyphosate. These include Health Canada, the European Food Safety Authority (EFSA), the European Chemicals Agency, Germany's Federal Institute for Risk Assessment, and the Food and Agriculture Organization of the United Nations, as well as health and regulatory agencies of France, Australia, New Zealand, Japan, and Brazil.

How has a chemical that has been exhaustively reviewed by regulatory agencies all over the world and repeatedly found to be safe become a vehicle for a torrent of lawsuits?

To answer this question, the place to start is IARC, which in March 2015 classified glyphosate as a "probable carcinogen" based primarily on what it termed "sufficient evidence" in rodent studies. However, revelations by the Reuters journalist Kate Kelland, and documents made public in the Monsanto lawsuits, paint a different picture from that presented by IARC regarding the agency's process in initiating and producing the report and its conclusions.

Unlike virtually all other agencies, IARC engages in hazard assessment rather than risk assessment. This means that IARC considers any scientific evidence of possible carcinogenicity, no matter how difficult to interpret or how irrelevant to actual human exposure. In doing so, the agency ignores a cornerstone

of toxicology that states "the dose makes the poison." The agency's approach fails to distinguish between exposures as they occur in the real world and far-fetched and improbable scenarios, and this in turn leads to an upward skewing of evaluations in terms of risk. (Unsurprisingly, then, of roughly 500 agents and chemicals evaluated by IARC, only one, caprolactam, a chemical used in the manufacture of synthetic textiles, was found unlikely to be carcinogenic). The problems with the IARC glyphosate classification, however, cannot be explained primarily by the distinction between hazard and risk evaluation.

How has a chemical that has been exhaustively reviewed by regulatory agencies all over the world and repeatedly found to be safe become a vehicle for a torrent of lawsuits?

First, IARC based its "probable carcinogen" assessment primarily on the results of studies in rodents, because the agency considered the human evidence "limited." However, independent analysis (by a former statistician at the US National Cancer Institute, Robert Tarone) of the rodent studies relied on by IARC showed no consistent or robust evidence of increased tumor yields in exposed animals. The IARC Working Group that conducted the assessment selected a few positive results in one sex and used an inappropriate statistical test to declare some tumor increases significant. Comparable inverse associations, some statistically significant, were ignored.

Second, IARC was aware of the availability of relevant results regarding non-Hodgkin's lymphoma (NHL) from the large National Cancer Institute-funded Agricultural Health Study (AHS), a prospective study of 54,000 pesticide applicators in Iowa and North Carolina. Although only very early results for glyphosate and NHL from the study had been published when the IARC Working Group met to evaluate glyphosate, a senior investigator on the AHS served as chair of the group. This scientist would have been aware that updated results from the AHS showed no significant increases for NHL from glyphosate exposure.

IARC argues that these results were not included in its 2015 assessment of glyphosate due to its rule that excludes unpublished findings. However, if the objective was to produce a valid assessment of glyphosate, this explanation is inadequate. The characteristics and methods of the AHS were widely known, and the details of the statistical methods used in the analysis of NHL had been described in a 2014 paper. Given that the existence of high-quality results from a large, carefully designed prospective study—precisely the type of human evidence that regulators most value—was known to at least one member of the Working Group, IARC's decision to proceed with the report but ignore the existence of the AHS results requires a more forthcoming explanation. Indeed, when the results for glyphosate and cancer incidence in the AHS were finally published in the *Journal of the National Cancer Institute*, in 2018, the paper reported no significant increases for more than 20 solid or lymphopoietic malignancies, including NHL and several NHL subtypes.

Third, in the past two years other improprieties in IARC's glyphosate assessment have come to light. Kate Kelland of Reuters examined drafts of the chapter of the monograph devoted to animal studies and found that early drafts more accurately summarized the evidence, whereas later drafts progressively emphasized findings that appeared to indicate a positive association.

Finally, the role played by Christopher Portier in the glyphosate assessment has become apparent in transcripts from litigation involving Monsanto. Portier, an American scientist who had worked for the federal government, chaired an IARC committee that prioritized glyphosate as an agent to be evaluated, and subsequently served as an invited specialist on the Working Group that evaluated glyphosate. Although IARC is hyper-alert to conflicts of interest involving industry, the agency seems not to be concerned about anti-industry bias. Two weeks after publication of the IARC report, Portier signed a lucrative contract to act as a litigation consultant with a law firm—Lundy, Lundy, Soileau, and South—engaged in bringing lawsuits against Monsanto for Roundup exposure.

In sum, IARC's classification of glyphosate diverged from the conclusions of other agencies worldwide, and the divergence resulted from a flawed assessment of the scientific evidence by the IARC Working Group.

A powerful counter-narrative

How can a respected scientific agency and its supporters take such a different view of the safety of Roundup/glyphosate from the mainstream?

Although glyphosate spraying has been practiced since 1974, its use has increased almost 15-fold globally since the 1996 introduction of "Roundup-ready" genetically engineered, glyphosate-tolerant crops. As a result, use of Roundup and cultivation of genetically modified foods have become indissolubly linked not just in agricultural practice but in public debates about genetically modified organisms (GMOs). Indeed, a powerful alliance of groups that oppose agricultural biotechnology has entered the fray concerning the carcinogenicity of glyphosate. These groups are anti-GMO, anti-pesticide, and anti-Big Ag, favoring instead natural farming and organic foods. One prominent organization is US Right to Know (USRTK), funded by the Organic Consumers Association, which advocates for organic agriculture while opposing genetic engineering—as well as, it might be noted, vaccines. USRTK and similar groups, including GM Watch, the Environmental Working Group, Greenpeace, and many others, ignore the enormous body of evidence that demonstrates the benefits of genetic engineering of crops, for example through improved tolerance to drought, increased re-

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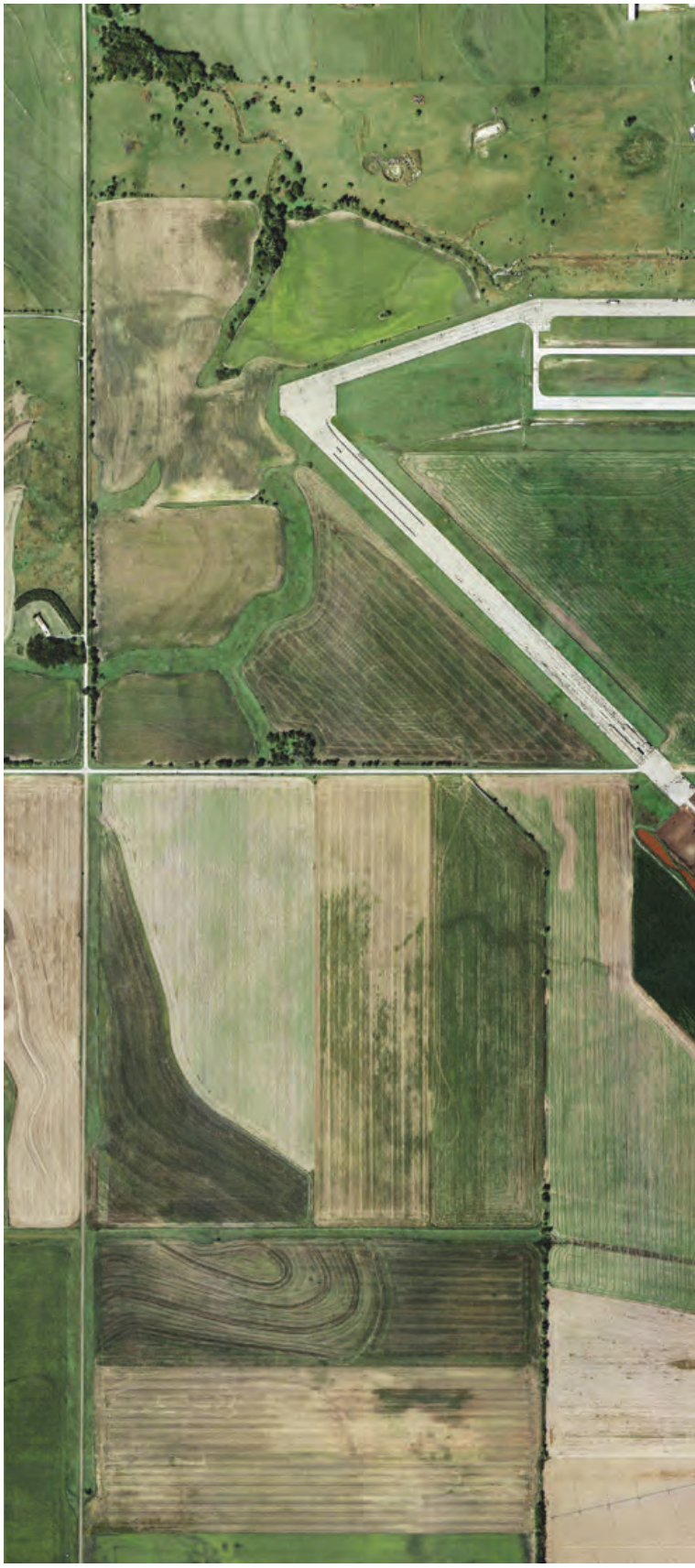
Mishka Henner
Feedlots

Mishka Henner is a Belgian artist who lives and works in Manchester, England. He is known for prints and videos that appropriate image-rich technologies, including Google Earth, Google Street View, and YouTube. He described his inspiration and process for creating the *Feedlots* series for the *Los Angeles Times*:

> I first came across these feedlots on Google Earth and had no idea what I was seeing. The mass and density of the black and white dots seemed almost microbial. To understand what they were I had to learn about the meat industry and its methods for maximizing yield in the minimum amount of time for the highest profit.
>
> It used to take five years for a cow to reach its mature weight, ready for slaughter and processing. Today, since the structures and processes of feed yards have been perfected, that has been reduced to less than 18 months.
>
> Such speed requires growth hormones and antibiotics in cows' diets, and efficient feedlot architecture. Farmers can turn to reports to help calculate the maximum number of cattle that can fit in each pen, the minimum size of run-off channels that carry away thousands of tons of urine and manure, and the composition of chemicals needed to break down the waste as it collects in lagoons and drains into the soil. Different chemical mixes explain the varying toxic hues of each lagoon.
>
> These pictures were made by stitching together hundreds of high-resolution screen shots from publicly accessible satellite imaging software. The results are prints of great clarity and detail that capture the effects of feedlots on the land.
>
> The meat industry is a subject loaded with a moral and ethical charge. But when I think of these pictures, I don't just see gigantic farms, I see an attitude toward life and death that exists throughout contemporary culture. These images reflect a blueprint and a horror that lie at the heart of the way we live.



Henner's work is currently on view at the Fraenkel Gallery in San Francisco; the National Gallery of Victoria in Melbourne, Australia; and the Galleria Bianconi in Milan, Italy. More information is available at the artist's website: https://mishkahenner.com/. Images courtesy of the artist.

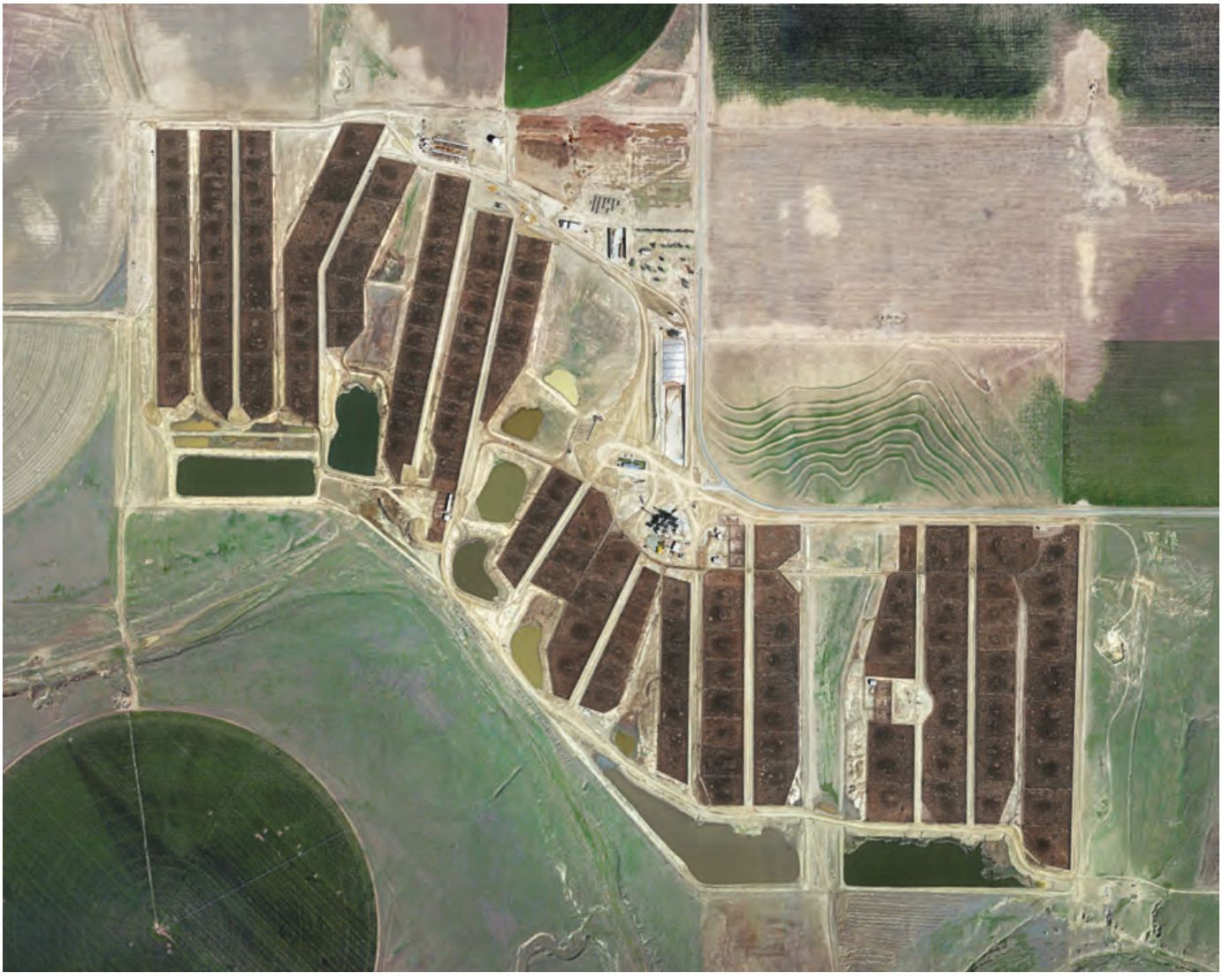
MISHKA HENNER *Black Diamond Feedyard, Harrington, Texas*, 2013, archival pigment print, 59 x 102 inches

MISHKA HENNER *Tascosa Feedyard, Bushland, Texas,* 2013, archival pigment print, 59 x 102 inches

sistance to pests, and enhanced nutrient content (as in the case of Golden Rice). Now the low-toxicity pesticides that enhance the value of GM crops are in the crosshairs as well. To these groups, IARC represents the sole agency that has not been corrupted by making compromises with industry.

Anti-GM agriculture groups have been waging an all-out campaign on their websites and in social media attacking journalists, scientists, and agricultural experts who defend modern farming and criticize IARC, alleging that they sow misinformation, ignore evidence of risks, and are compromised by conflicts of interest. Their targets have included academic experts Nina Fedoroff of Penn State, Kevin Folta of the University of Florida, Drew Kershen of the University of Oklahoma, Alison Van Eenennaam of the University of California, Davis, and many others (including myself). To counter the activist anti-GMO, anti-pesticide organizations, groups such as the Genetic Literacy Project, the American Council on Science and Health, and the Cornell Alliance for Science, see their mission as trying to explain the science and its implications on these contested topics to the public.

What distinguishes the two sides is that the latter groups pay more attention to the quality of the scientific evidence and are interested in gene editing, development of more resilient crop varieties, strategies for reducing pesticide use, and other advances that have the potential to feed more people with fewer chemical inputs using less land. In contrast, the former groups tend simply to assert that there are serious risks associated with genetic engineering of plants and animals and with pesticides, and to tar all who disagree as being associated with agrichemical companies and their front organizations. They don't have to



MISHKA HENNER *Centerfire Feedyard, Ulysses, Kansas*, 2013, archival pigment print, 59 x 102 inches

point to any substantive evidence of the implied risks or cover-ups. They don't have to distinguish between solid studies and those that are questionable. All that's needed is to assert that the figures they single out are part of a sinister and corrupt network featuring, as USRTK says, "secret financial arrangements and close collaborations between corporations, their PR firms, and supposedly 'independent' academics who promote corporate interests."

In addition, both American and European activists have been lobbying bureaucrats and politicians in the European Union to have glyphosate banned. Christopher Portier and Carey Gillam, a spokesperson for USRTK, have testified before the European Parliament in support of a ban. The European Union provides fertile soil for activists opposed to modern agricultural practices because it has enshrined the "precautionary principle" as part of its regulatory framework. As explained in a 2017 European Commission document, the precautionary principle allows that "regulatory intervention may still be legitimate, even if the supporting evidence is incomplete or speculative and the economic costs of regulation are high." IARC, by declaring glyphosate a probable carcinogen, provides groups such as USRTK the authoritative scientific cover they need to pursue their campaign against Bayer and in support of a glyphosate ban. In California, the IARC findings allow the state to list glyphosate as a carcinogen under its 1986 Safe Drinking Water and Toxic Enforcement Act, better known as Proposition 65, and thus provide an apparent scientific basis for litigation.

More broadly, IARC's flawed assessment both relies on and lends apparent scientific credibility to a variety of powerful beliefs and biases that infect the public discussion of environmen-

tal exposures to chemicals such as glyphosate. By bracketing out much of what is known about the causes of cancer and by focusing people's attention solely on what are trace environmental residues, activist organizations reinforce these beliefs and biases, which seem prevalent enough to merit being labeled "memes." From my own work, and building on decades of research by decision scientists such as Paul Slovic, Cass Sunstein, Daniel Gardner, and Peter Sandman, I identify at least four such memes:

IARC's flawed assessment both relies on and lends apparent scientific credibility to a variety of powerful beliefs and biases that infect the public discussion.

- many scientists are subservient to multinational corporations, which are congenitally dishonest, and focused solely on profit;
- industry-funded research is biased and must be discounted, while research funded by advocacy groups, government agencies, and universities is unbiased and can be trusted;
- people are being poisoned by trace contaminants in their food, water, and the environment, and this contamination is responsible for many diseases; and
- genetically engineered crops could introduce dangerous pathogens into the food chain and the human population.

In the case of glyphosate, 40 years of science demonstrating the safety of the chemical is quite consistent and is supported not only by industry-affiliated scientists but by independent scientists, including agricultural experts, toxicologists, and regulatory officials who are familiar with pesticide use, as evidenced by the fact that so many regulatory bodies worldwide are in agreement. Why, then, are the attacks on glyphosate in courtrooms and governments succeeding? Part of the explanation of course is that the widely shared memes I cite allow advocacy groups and others skeptical of GM crops and agrochemicals to discount the body of science documenting glyphosate's safety and focus entirely on the IARC assessment.

Science divided

The more interesting and difficult question is why a substantial number of scientists appear to support the IARC assessment. Indeed, a November 2015 letter to the European Commissioner for Health and Food Safety signed by 96 scientists attacked the European Food Safety Authority's determination that glyphosate was not carcinogenic, and supported IARC's contrary determination.

But Bernhard Url, the head of EFSA, in an address to his organization, provided a different perspective: "People that have not contributed to the work, that have not seen the evidence most likely, that have not had the time to go into the detail, that are not in the process, have signed a letter of support [for a ban on glyphosate]. Sorry to say that, for me, with this you leave the domain of science, you enter into the domain of lobbying and campaigning. And this is not the way EFSA goes."

It's possible to understand why scientists without direct and deep expertise on a specific subject might weigh in through such a letter. Because, of course, scientists are human too. Scientists who have worked with IARC appear to feel a strong loyalty to the institution and rally to its defense, often without appearing to know the details of the substantive criticisms that have been made by outside scientists. But if loyalty to IARC and alignment with its mission can explain the support of IARC's broad base, it is still necessary to explain how the IARC leadership that organized and oversaw the glyphosate review can defend their position. Here, it is difficult to escape the conclusion that there are bigger issues at stake than the narrow interpretation of the evidence regarding glyphosate.

My own belief is that an extreme precautionary approach to evaluating risks is at the root of both the recent conduct of the IARC program to identify human carcinogens and that of IARC-associated epidemiologists who are, it seems, often willing to give weight to evidence from weak observational studies and from other types of studies that appear to point to a risk. It must also be said that being in a position to make authoritative pronouncements about risks that are of public concern is not a negligible source of influence and career advancement. Because of their political or professional stake in the issue, scientists may find particularly credible and draw attention to certain studies that purport to show an association, while ignoring other higher-quality studies. For example, an expert providing testimony for the plaintiffs in one of the Monsanto cases cited crude case-control studies of glyphosate as evidence that exposure is associated with increased risk of NHL, while ignoring the higher-quality findings of the Agricultural Health Study. A recent paper in the journal *Mutation Research* combined five small case-control studies with the much larger AHS results in a meta-analysis, and, by selecting only the highest of five risk estimates from the AHS, the authors asserted that exposure to glyphosate increased the risk of NHL by 41%. If they had included the other estimates, there likely would have been no risk. One could give many more examples of this kind of selective approach to the evidence.

Of course, other scientists may have biases that push in the other direction, sometimes indeed because their interests or sympathies lie with industry, or with farmers. But that's why scientists representing a variety of institutional perspectives need to be included in any process to assess small environmental risks in large populations using complex statistical tools. And failure to have such representation sets IARC apart from the many other environmental risk assessment bodies that have concluded that glyphosate does not pose a cancer risk.

MISHKA HENNER *Coronado Feeders, Dalhart, Texas*, 2012, archival pigment print, 59 x 102 inches

MISHKA HENNER *Friona Feedyard, Parmer County, Texas,* 2013, archival pigment print, 59 x 102 inches

Facebook science in action

For years, IARC has positioned itself as the voice of independent scientific authority on the carcinogenicity of physical, chemical, and biological agents. When specific assessments of IARC have been questioned or criticized by qualified scientists, the agency's default response has been to assert its preeminent position and its authority, rather than to address the specific substantive criticisms or engage in a discussion of the evidence on its merits. In addition, IARC and its defenders typically argue that any criticism must be motivated by conflicts of interest and subservience to industry. For example, an article published in 2015 in the journal *Environmental Health Perspectives* titled "IARC Monographs: 40 Years of Evaluating Carcinogenic Hazards to Humans," signed by 124 authors, sought to win the public debate by insinuating that critics of IARC have venal motives. Yet the article consistently failed to address legitimate specific points raised by critics.

This pattern of refusing to engage in a discussion of the evidence for its classifications goes back more than 10 years. In the most recent publications of IARC supporters addressing the glyphosate issue, the authors restate yet again IARC's conscientious approach to its mission, focus on alleged questionable behavior by Monsanto, and imply that IARC's critics have conflicts of interest. However, they continue to avoid discussing the evidence and ignore the fact that all other regulatory agencies have found glyphosate to be safe and noncarcinogenic. Nor, with the exception of acknowledging Portier's becoming a litigation consultant immediately after publication of the glyphosate assessment, do they acknowledge any of the other irregularities pertaining to the glyphosate report.

IARC's supporters in the scientific community consistently paint a picture of selfless scientists motivated by protecting public health pitted against powerful corporations aided by compliant scientists and politicians. Quite intentionally, this Manichean picture leaves no room for a discussion of the scientific evidence on its merits. You are either for IARC and "science" and "public health," or you are okay with corporations assaulting public health because they don't care if people get cancer so long as they get profits. There is no middle ground. What needs emphasizing, however, is that the effect of IARC's strategy is to transform a debate about science and evidence into a crusade for moral and political purity against which there can be no defense. In this highly polarized climate, those who see things differently may be reluctant to speak out.

The memes that shape people's—including some scientists'—views on complex issues of risk coalesce, and reinforce and amplify each other, contributing to what the Nobel Prize–winning behavioral psychologist Daniel Kahneman terms an "availability cascade ... a self-sustaining chain of events, which may start from media reports of a relatively minor event and lead up to public panic and large-scale government action." This cycle, he adds, "is sometimes sped along deliberately by 'availability entrepreneurs,' individuals or organizations who work to ensure a continuous flow of worrying news. The danger is increasingly exaggerated as the media compete for attention-grabbing headlines. Scientists and others who try to dampen the increasing fear and revulsion attract little attention, most of it hostile: anyone who claims that the danger is overstated is suspected of association with a 'heinous cover-up.' "

Under such circumstances, positive studies or assessments, such as IARC's assessment of glyphosate, reinforce the prevailing beliefs and fears, while negative studies or assessments, such as those of the other government organizations that do not reveal a cancer risk, fail to find a receptive audience. The availability cascade has in turn led to the juggernaut of litigation cases against Monsanto/Bayer, each one enacted as a morality play in which a plaintiff with a rare, poorly-understood cancer is pitted against a powerful corporation.

In this case, the "availability entrepreneurs" include IARC itself, along with some scientists, advocates, plaintiffs' lawyers, and nongovernmental organizations with an agenda (and, it should be said, with their own set of financial interests, such as funding from the organic foods industry and manufacturers of "green" environmental products). Collectively, they spin the evidence for their purposes. The result is what EFSA's Bernhard Url has termed "the Facebook age of science." As he put it: "You have a scientific assessment, you put it on Facebook, and you count how many people 'like' it. For [EFSA], this is no way forward. We produce a scientific opinion, we stand for it, but we cannot take into account whether it will be liked or not."

The glyphosate controversy may be the most glaring example of Facebook science, but it should come as no surprise that the same factors that are at work here are at work in many other areas, whether electromagnetic fields, cell phone "radiation," so-called endocrine disrupting chemicals, numerous aspects of diet, cosmetic talc, GMOs, vaccines, nuclear power, or climate change.

Today's highly interconnected world faces serious problems that are in large part the result of the unprecedented progress that has been made over the past 150 years in science, technology, public health, and nutrition. These problems include, among others, the emergence of new pandemic virus strains and increasing antibiotic resistance; degradation of the environment, leading to loss of habitat and loss of species diversity; the challenge of producing adequate food for a growing population; and the pressing need to transition to a realistic energy policy as part of a response to a changing climate. These challenges will not be met by appeasing activists who seem to believe that the world would be better off today without many of the scientific and technological advances of the past, who exaggerate the risk associated with those advances by misrepresenting the scientific evidence, and who have nothing to offer but the simplistic and moralistic narratives of Facebook science.

I realize that complex issues of risk and the environment create a near-impenetrable thicket of uncertainties, values, interests, and competing experts' views of the evidence. But sometimes the clear weight of evidence coupled with a dose of common sense is enough to show what's right, even if that means going against the tide of popular outrage. Glyphosate is a boon to agriculture and humanity. Let's refocus the energy and resources spent on trying to demonize this useful and valuable chemical on problems that really matter.

Geoffrey Kabat *is a cancer epidemiologist and the author of* Getting Risk Right: Understanding the Science of Elusive Health Risks.

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