Controversies in Science and Technology

From Maize to Menopause

Edited by
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Agricultural Antibiotics

Features of a Controversy

Brian Martin

Is using antibiotics in livestock and poultry problematic? Critics say that this practice is contributing to antibiotic resistance, with potential risks to human health. Defenders say the risk to humans is exaggerated and that the benefits outweigh the risks. Surely this disagreement can be sorted out in a straightforward fashion: just collect the scientific evidence and make a judgment. But, unfortunately, things are not this easy.

Social scientists have been studying what are called "scientific controversies" for quite some time (Collins 1981; Mazur 1981; Nelkin 1979). This includes debates about supersonic passenger aircraft, nuclear winter, genetic engineering, solar neutrinos, continental drift, greenhouse effect, cancer treatments, and microwave radiation. Some of these controversies largely occur between specialist scientists, such as between physicists who hold different views about gravity waves (Collins 1985). Sometimes specialist disputes spill out into the public arena, such as the controversy about cold fusion, which has implications for energy production (Simon 2002). And sometimes social implications are central to the dispute, as in controversies about pesticides and nuclear power. The antibiotics-in-farm-animals controversy fits in here.

When both scientific and social dimensions are involved, it is possible to say that a social controversy accompanies a scientific controversy (Engelhardt and Caplan 1987). But separating these two dimensions is

not easy, and it may be more sensible to say that the scientific and social aspects are intertwined in a given controversy. What really animates a controversy is the connection between knowledge and power. A controversy is more than an intellectual disagreement because of the tight connection between scientific knowledge and power-related factors such as reputations, careers, positions of authority, profits, policies, and social control. One important implication is that scientific evidence, on its own, can never resolve the controversy. Evidence can always be disputed and theories are always open to revision, so disputes can persist so long as participants are willing to pursue them. Rather than thinking of evidence as the definitive means for resolving controversy, it is more useful to think of evidence as a tool—along with other tools, such as money, connections, authority, and eloquence—that can be deployed in an ongoing struggle.

Here I present a number of generalizations about scientific controversies, based on previous research. For each generalization, I give a few examples from other controversies—especially those, such as fluoridation, that I have studied in depth—and then offer an assessment of its relevance to the controversy about antibiotics in livestock and poultry. When reading the other chapters in this section, as well as throughout the book, it will be helpful to bear in mind these typical features of a scientific controversy as the authors stake out their positions.

A Range of Arguments

The arguments used in a typical scientific controversy fall into a range of categories, for example, scientific, ethical, economic, political, and procedural. In making sense of the controversy, it is often helpful to distinguish and classify the different types of arguments, recognizing that categories sometimes overlap.

In the long-running debate about fluoridation, which involves adding fluoride to public water supplies as a means to reduce tooth decay in children, participants make four main types of argument (Martin 1991). First, the benefits of fluoridation: advocates say that they are significant, whereas critics say that they are overstated. Second, the risks of fluoridation: advocates say no significant hazards exist; critics cite evidence about dental fluorosis, allergic and intolerance reactions, and potential genetic effects. Third, ethical considerations: advocates say fluoridation is ethical because it improves the dental health of children whose parents cannot

afford dental treatment; critics say that it is unethical to medicate a population with an uncontrolled dose of fluoride. Fourth, decision making: advocates say that governments, advised by dental experts, should make decisions about fluoridation; critics say that the public should be directly involved in decision making.

In the controversy about the farm use of antibiotics, a central argument concerns human health: is antibiotic use in livestock and poultry leading to human resistance to antibiotics that are important for controlling pathogens? This includes various scientific arguments about the paths by which antibiotic resistance that developed in animals can be transferred to humans, the relative contribution of medical and animal use of antibiotics to the development of human resistance to antibiotics, and the effect of banning specific animal antibiotics. (See chapters by Salyers and Singer for two different scientific views about the risks to human health).

Another key argument concerns the economic benefit of using antibiotics in animals. This is linked to various scientific issues, such as questions concerning the effectiveness of the therapeutic, prophylactic, and growth-promoting uses of antibiotics. A lesser argument, somewhat behind the scenes, concerns who should make these decisions: farmers, governments, scientists, or someone else? Furthermore, whose advice should prevail? How should potential risks be judged?

Claims about human health are potent tools in public debate, which seems to be why critics of animal antibiotics highlight them: doing so puts supporters of these antibiotics on the defensive, arguing that the link to human health has not been sufficiently established. This is an example of the power-knowledge connection in controversy, with the agenda for scientific dispute in part set by what has saliency in the public arena.

Another sort of argument commonly used in controversies is to point to authorities—experts, professional associations, governments—that have taken positions in support of one's own. This can be called the argument from authority, which is not really an argument at all but an encouragement to defer to those particular authorities. Critics of agricultural antibiotics use the argument from authority when they point to European government regulations that ban the agricultural use of particular antibiotics such as avoparcin in the Netherlands, and when they refer to statements by professional bodies such as the American Medical Association (see Barlam in this volume). Those on the other side attempt to neutralize these endorsements by focusing on the evidence itself, for example, by

pointing to differences between European and U.S. agriculture. (Singer, in this volume, points out these differences).

Endorsements sometimes follow one another in a bandwagon effect, with governments or professional bodies seeking guidance or drawing inspiration from each other. Nevertheless, it is possible for controversies to stabilize, with different countries or regions taking different positions. The fluoridation controversy has persisted for decades with high levels of fluoridation in most English-speaking countries and very little in Europe. Similarly, it is quite conceivable that a similar contrast between animal antibiotics policy and use in the United States and Europe could develop and persist. This is an example of how "the evidence" may be insufficient to resolve a controversy.

Coherent Arguments

In polarized debates, everyone lines up on one side or another, with hardly anyone left in the middle ground. In terms of arguments, this means that most partisans will use every possible point to support their position. The result is "coherent arguments," with views about different types of arguments lining up like iron filings in a magnetic field.

The fluoridation debate has been highly polarized. Proponents say that fluoridation has large benefits, no risks, is ethical, and that governments should make the decision on the advice of dental experts. Opponents take every contrary position possible. It is hard to find anyone who says, for example, that fluoridation has no risks but is unethical.

Debates are likely to become polarized when stakes are high. Stakes include money, commitment, prestige, and credibility. Key partisans often develop a psychological attachment to their position. To succeed, they draw on every bit of positive evidence and every doubt about contrary evidence. Those who adopt a middle position are likely to come under pressure to support one side or the other.

The antibiotics-in-farm-animals debate seems to be moderately polarized, judging by the way that most commentators line up with one set of arguments or another. Those on one side are likely to adopt a group of positions that emphasizes risks to human health, does not rate highly the economic benefits of antibiotics as growth promoters, and supports European governments that regulate against such antibiotic use. Those on the other side are likely to adopt a contrary group of arguments that empha-

sizes scientific uncertainties about the effect on human health, assumes significant economic benefits from using antibiotics to promote animal growth, and supports the U.S. regulatory system, which gives industry strong leverage over policy. Critics deploy or deride the scientific arguments, depending on their stance. For example, they see the European evidence as relevant—or not—to the United States, and they regard the causal pathways along which antibiotic resistance moves from animals to humans as either a cause for concern or as not sufficiently established.

Rarely does a commentator say that using antibiotics to promote growth in farm animals poses serious risks to human health but that farmers should be able to use antibiotics as they see fit, or, on the other hand, that human health risks are minimal but so are the economic benefits of animal antibiotics compared to the alternatives. According to the report of a 2001 colloquium held by the American Academy of Microbiology, the participants agreed that there was a "strong polarization of views" about the effects of agricultural antibiotics (Isaacson and Torrence 2001, 6).

Some scientists present themselves as neutral commentators, providing facts but not opinion. Reservoirs of Antibiotic Resistance (ROAR) describes itself as a "network dedicated to generating a new impetus worldwide for research on commensal bacteria as reservoirs of resistance that can be transferred to human pathogens." One of its two stated key objectives is to "act as the definitive source of information" on this topic. (http://www.tufts.edu/med/apua/ROAR/roarhome.htm; accessed May 24, 2004). Despite such worthy intentions, such scientists and groups are at risk of being drawn into the controversy when partisans on one side or the other, or both, draw on their material for campaign purposes. It is impossible to be perfectly neutral, because highlighting one fact rather than another can play into the hands of critics on one side of the debate. By focusing on antibiotic resistance, ROAR is likely to be more useful to critics of antibiotic use in agriculture. The more polarized the controversy, the less feasible it is to be a truly neutral commentator.

Alternatives

In a vociferous controversy, not only do the two sides become entrenched but so do the terms of the debate itself. In the debate about nuclear power, proponents were for nuclear power and opponents were against it—and both sides thought the question of nuclear power was

central. A few proponents tried to broaden the terms of the debate to the issue of safety, to be achieved by such means as different reactor designs or underground construction, but they received little attention. Similarly, a few opponents tried to broaden the terms of the debate by questioning the need for centrally supplied electrical power, proposing energy efficiency plus decentralized solar and wind power as alternatives, but they too were a minority voice.

A prominent controversy can operate like a vortex, sucking nearby issues into its framework and subordinating them. Winning the debate becomes so important to participants that they lose sight of wider purposes. The fluoridation debate has drawn attention away from alternative methods of combating tooth decay, such as reducing sugar in the diet.

Use of agricultural antibiotics has become an entrenched practice through corporate investment, skill development, and psychological commitment. Changing such a practice would be difficult, even supposing that an alternative means became available to achieve equal weight gains at lower cost, with no loss in animals' health status. That is because switching to the alternative would mean that different companies would reap economic benefits, workers would have to learn different routines (and some might lose their jobs), and everyone involved would have to think in different ways. This is the lesson from experiences with other entrenched technologies, for example, military weapons systems (Morison 1966).

Though some alternatives to agricultural antibiotics are available or in development—see Mlot, in this volume—the critics are not unified in endorsing a particular alternative. This means that there is no alternative interest group—a company that stands to profit from a big new market—to challenge the entrenched practice.

If the purpose of livestock and poultry production is the highest quality meat, this seems compatible with restriction of antibiotics to sick animals. Even assuming the purpose is industry profits, then restriction of antibiotics across the industry might not be detrimental. However, these apparently rational assessments stand little chance in the face of an entrenched technology. (The pharmaceutical industry, however, has nothing to gain economically from restrictions on antibiotics, unless demand for a more profitable alternative is created.)

From the point of view of those concerned about how human health is affected by antibiotic resistance, the focus on farm animals may seem a

distraction from reducing excess antibiotic use among humans, by far the greater source of antibiotic resistance. Also sidelined are more far-reaching alternatives, such as reducing the amount of meat that people eat, which would improve health in industrialized countries, reduce costs, and improve the environment. However, the meat-reduction alternative is far off the mainstream agenda and seldom mentioned in commentary on the antibiotics controversy.

The point here is not to endorse any particular alternative but rather to emphasize that controversies often have the effect of making the assumptions underlying the debate seem natural. It seems obvious to many participants that human health is the key issue in the use of animal antibiotics, but some people may well consider such issues as jobs or animal welfare to be of greater significance.

Partisans

A few high-profile partisans lead most controversies. This is especially true when the scientific content is significant. Individuals can become linchpins if they have some level of scientific capability and credibility, combined with a flair for powerful expression, public exposition, confrontation, and/or campaigning. Prominent examples are the scientist and science popularizer Carl Sagan and the physician Helen Caldicott in nuclear war–related debates. Such individuals may or may not be the central scientific figure; sometimes a charismatic personality can make up for scientific inadequacies.

The dynamics of debate helps create high-profile partisans. A person who makes a contribution—publishes a relevant paper, gives a talk, writes a popular article—is likely to be contacted by campaigners, invited to make further contributions, perhaps approached by the media. Such a person, if inclined, can become more actively involved, and in fact better qualified to do so, having received information, contacts, feedback, and encouragement. Those who develop a reputation may be asked to testify at hearings, speak at major meetings, or write an op-ed piece.

Is the debate about agricultural antibiotics led by high-profile partisans? One prominent Australian opponent is Peter Collignon, a microbiologist. Compared to the nuclear power or nuclear weapons debates at their peak this controversy is low key, not engaging all that many members

of the public. Media coverage is not intense. But if the debate becomes more prominent, a few partisans will become more visible as carriers of the public debate.

Although a few individuals receive disproportionate attention, especially in the media, the people behind the scenes actually keep campaigns going by collecting and circulating information, building networks, organizing meetings, raising funds, and acting as contacts for the media. These individuals might be called the campaigners, who can range from public relations executives in a well-funded campaign to low-paid or volunteer activists in a grassroots campaign. Occasionally, these campaigners are also high-profile partisans, but often the labor is divided. Campaigners may be less visible, but they are driving forces in many controversies.

Support

Who supports one side or another in a controversy, and why? In a perfectly rational and compassionate world, an individual would study the issues and decide which side to support on the basis of evidence and logic, in the context of universal values such as justice and human welfare. A few individuals approach this ideal, but in practice hardly anyone has the time, expertise, character, and independence of mind to make this sort of judgment. So if we turn to the practical realities of controversies, it is possible to observe the influences that shape the decisions of most of those involved.

A group is likely to support one side in a controversy if it is in its interests to do so. This is straightforward: pesticide manufacturers support pesticides; automobile manufacturers support road building; doctors support medical intervention. If a controversy is associated with a product or practice, the group almost always lines up accordingly. In the debate about the benefits and risks of pesticides, pesticide manufacturers defend pesticides and criticize alternatives. In debates about transportation planning, automobile manufacturers defend cars and roads and do little to advocate bike paths or public transportation. In debates about cancer treatment, the medical profession supports surgery, radiation, and chemotherapy and criticizes unconventional therapies.

When an organization takes a stand, its members are likely to follow. When corporate executives support pesticides, most employees will as well, because doing so is in their personal interest, namely, their jobs,

salaries, and peer support. Few group members take the time to carefully assess evidence and arguments on both sides. They simply follow cues from their superiors, perhaps taking note of materials prepared by their side.

The pharmaceutical and agricultural industries have developed interests in the regular use of animal antibiotics. Therefore it is entirely predictable that industry organizations and individuals will support this practice. For example, the Animal Health Institute, "representing manufacturers of animal health products" in the United States, features on its website (http://www.ahi.org) comments and articles criticizing the claim that animal and human antibiotic resistance are closely associated. On the other hand, public health workers, for whom the concerns of these industries are of no particular moment, are more likely to be critics of using antibiotics in animals. For example, the Union of Concerned Scientists, which has a long history of adopting public interest stands that challenge government or industry positions, issued a report titled *Hogging It!* (Mellon, Benbrook, and Benbrook 2001) that, among other things, criticizes work by the Animal Health Institute. The Union of Concerned Scientists features on its website (http://www.ucsusa.org/) "Myths and Realities About Antibiotic Resistance," in a question-and-answer format, that opposes most uses of antibiotics in farm animals.

Industry-funded researchers are likely to be supporters of antibiotics, whereas researchers with no ties to industry are less easy to predict. In a *Lancet* forum on antibiotic resistance, positions were predictable: all overtly industry-affiliated contributors supported industry use of antibiotics, whereas all critics of animal antibiotics were affiliated with universities or public health organizations (Singer et al. 2003).

The pattern of industry-related support for a scientific position is the most obvious aspect of the link between power and knowledge in a controversy, reflecting the adage that money speaks, even in science, though with the proviso that some scientists speak back. But this does not mean that arguments that serve powerful interests can be dismissed out of hand, only that these arguments warrant extra scrutiny.

Attacks

One of the less savory aspects of controversies is the exercise of power against opponents. For example, the nuclear industry has threatened,

reprimanded, compulsorily transferred, demoted, dismissed, and blacklisted employees who have exposed safety violations (Freeman 1981). The epidemiologist Thomas Mancuso was funded by the Atomic Energy Commission to do a study of the effects of low-level ionizing radiation; when he didn't come up with the findings that the commission preferred, it used a biased review process to withdraw his funding (Bross 1981, 217–22).

Attackers use whatever resources are at their disposal: rhetorical, personal, editorial, economic, and political. They may attack their opponents verbally, in overt abuse or through hard-to-trace rumors. When the opponent is a subordinate—such as when an employee exposes unwelcome data—attacks can take the form of ostracism, petty harassment, threats, or physical intimidation. Editors and referees can use their power over publication to block opponents' submissions. Some opponents lose their jobs or grants. In some cases, they may find themselves publicly denounced in the media.

These and other methods of attack—constituting what may be called "suppression of dissent"—seem to be especially prevalent when dissident experts provide support to a social movement that is challenging a powerful interest group, as in the cases of nuclear power, pesticides, and fluoridation (Martin 1999). Each side may attempt to attack the other, but often one side has a preponderance of resources. This is a stark example of how power can affect the search for and expression of knowledge.

In 2003, Dr. Ruth Hall, a leading researcher on antibiotic resistance, lost her job at the Commonwealth Scientific and Industrial Research Organization, the major Australian government research body. Commenting on this, Dr. Graeme Laver of the Australian National University was quoted as saying, "It did occur to me, I am afraid, that commercial pressures of some sort may have been responsible. We all know that Dr. Hall has made many statements on television, in the press and so on, that the practice of feeding antibiotics to livestock in order to promote growth might lead to antibiotic-resistant bacterial pathogens which would adversely affect human health" (Schwartz 2003). In this case, like many others, the evidence is insufficient to prove suppression of dissent, though it is compatible with such an interpretation. Subtle and deniable attacks are more effective than blatant ones, which can cause outrage.

Significant dissent is rare. Few people make public statements about their employer or about the viewpoint dominant among their colleagues. In the tobacco industry, for example, despite decades of covering up find-

ings damaging to the industry (Glantz et al. 1996), very few employees ever spoke up. Therefore, it is reasonable to expect that few, if any, pharmaceutical industry employees will publicly voice criticism of the use of antibiotics, and that those who do will suffer reprisals (Abraham 1995). However, university scientists face less risk in making public comment, especially because neither side in the dispute has a preponderance of support.

Evidence

When a controversy involves science, a natural reaction is to say, "Let's collect some more evidence, and that will resolve the dispute." Controversies seldom conform to this logical approach. Indeed, new evidence often has no major effect on the dynamics of a controversy.

During the controversy about whether vitamin C can help in the treatment of cancer, a major study showed that the vitamin had no benefit to cancer patients. However, the scientists supporting vitamin C refused to accept the findings. Instead, they argued that the study was flawed in its method of choosing subjects and administering the vitamin (Richards 1991).

Evidence is not the "answer" to controversies for several reasons. Someone can always challenge the evidence: the results may be due to experimental flaws, misinterpretation, or chance variation. Each side in a dispute interprets the evidence through its own conceptual lens, typically dismissing contrary findings as inadequate or irrelevant and pouncing on favorable findings as significant or definitive. Partisans in controversies usually develop a strong psychological commitment to their position.

In the case of controversies with important social dimensions, new evidence is even less likely to be definitive because ethical, political, economic, or other dimensions to the issue remain contentious. In the case of the fluoridation debate, some opponents said that they would remain opposed even if fluoridation were completely safe, because it involved compulsory medication.

If the power-knowledge connection is central to scientific controversies, it is not surprising that knowledge alone is insufficient to transform the debate. Rather than thinking of evidence as a basis for resolving a controversy, it can be more useful to think of evidence as a tool that partisans use in their efforts to win support. Evidence is part of each side's "resource

tool kit," along with eminent endorsers, money, alliances, and commitment by key partisans.

Based on this assessment, we can predict that new evidence will not greatly affect the debate about agricultural antibiotics. If new evidence becomes available that supports one side, that side's partisans will strongly declare its relevance and significance, but they are likely to be disappointed that the evidence has so little influence.

Closure

If evidence is insufficient to resolve a controversy, what does bring it to an end? This is the issue of "closure" (Engelhardt and Caplan 1987). Sometimes partisans on one side lose interest or energy; some retire or die. Sometimes the weight of opinion is so one-sided that the weaker side is marginalized into near invisibility.

Where social controversy is strong, its fate is often determined by decisions by powerful groups, even though scientific issues remain unresolved. In the 1980s, debate raged about nuclear winter, a drastic reduction in atmospheric temperatures claimed to be likely after a nuclear war. With the end of the Cold War in 1989, the entire issue dropped from sight, although the scientific issues were never resolved.

The debate about agricultural antibiotics might reach closure in several ways. One is that governments ban the use of antibiotics as growth promoters; the European Union is taking this approach in part. Another is that key purchasers demand antibiotic-free meat. The June 2003 announcement by McDonald's that it would ban or discourage use of antibiotics by its meat suppliers was a major shift in the controversy. The scientific issues did not need to be resolved for McDonald's to make a decision informed by its own interests, namely, enhancing its reputation as a provider of food that has minimal negative effects on the environment and health. A dramatic expansion of organic farming, which prohibits growth promoters, could also help move the debate toward closure.

Another way that the controversy could end is by development of alternative ways to promote animal growth. Indeed, a ban on antibiotic growth promoters could stimulate investigation into alternatives, such as probiotics, thus making the animal antibiotic debate irrelevant. It is also possible to imagine scenarios in which animal antibiotic use becomes more widely accepted, for example, as a result of introducing new animal

antibiotics that are unrelated to human antibiotics or as a result of a declining concern about antibiotic resistance in general because other issues take priority. Dissemination of animal or human disease vectors by terrorists could affect the debate in unpredictable ways.

The aim here is not to predict the future but to point out that what is called a scientific controversy can reach closure by a variety of means, including political and economic processes—another feature of the intertwining of power and knowledge in such controversies. But it is unwise to assume that a debate is gone forever. With changed circumstances, a moribund issue can pop up again, with renewed contention, for example, as a result of claims that a surge in human disease is related to animal antibiotic resistance.

Conclusion

Different scientific controversies have many similarities, though each has its own special characteristics. For those who are partisan participants in a controversy, studying the dynamics of related controversies may be helpful for picking up ideas about how to be more effective. Partisans typically believe implicitly that they are correct in their stances, so the main thing they need to learn is how to do better in their advocacy.

Outsiders, though, may not care which side "wins." They may just want to know how to make sense of the clash. When experts disagree, how can a nonexpert decide? Looking at general treatments of controversies can help to explain some recurring patterns.

Policy makers have a more urgent problem: what to do now. It is tempting to wait for more evidence, and scientists often advocate further research (Isaacson and Torrence 2001, 12–13 and chapters by Salyers and Singer, in this volume). But, as I described the process earlier, new evidence seldom resolves a controversy. In any case, policy has to address not only evidence but also the wider social dimensions of the issue. That means making value judgments, such as when benefits to one group cause risks to another. Antibiotics bring benefits to agricultural producers now, with a potential but unknown risk to people in the future. There is no purely scientific way to weigh competing claims.

Policy making is no more a neutral process than is the debate about antibiotic resistance, especially because policy makers are under pressure from various groups. Furthermore, to even speak of "policy makers" is to

make assumptions about who makes policy: is it government agencies, legislatures, the market, elite scientists, or some form of direct public participation? Intertwined with scientific controversies are implicit assumptions, and sometimes overt debates, about how decisions should be made. It is anyone's prerogative to join the public debate about agricultural antibiotics. Studying the dynamics of scientific controversies can offer some hints for being a more effective participant.

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