**Appendix E - UNIVERSITY HONORS PROGRAM**
**SENIOR PROJECT - APPROVAL**

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PROJECT TITLE: Antibiotics in the Beef Industry:
Philosophical and Scientific Perspectives

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

Signed: _____, Faculty Mentor

Date: 05/02/02

General Assessment - please provide a short paragraph that highlights the most significant features of the project.

Comments (Optional):

Rachels project is on an important issue that impacts all of us — antibiotic resistance. Development of antibiotic resistance in bacteria is a very controversial topic and one that invokes a lot of passion depending upon your perspective. I thought Rachel did a good job of blending philosophy with science.

Stephen A.

# Antibiotics in the Beef Industry:

## Philosophical and Scientific Perspectives

Rachel Hart

Senior Honors Project

A current issue that has received growing attention lately is food safety. Wary consumers are increasingly questioning the effects of growth hormones, pesticides, antibiotics, and other substances utilized in the production of many types of foods. Antibiotics are significant because their use can lead to antibiotic resistance, and the extent to which resistance in food animals can be passed to humans is now cause for concern. In the beef industry, the use of antibiotics is necessary to produce the amount and quality of beef that the market demands. Each step in the current production of beef is meant to be maximally efficient with minimal cost, and this philosophy has produced conditions within the beef industry that require antibiotic use for the production of beef. As resistance to antibiotics is a growing problem, solutions to reduce the number of antibiotics used in the beef industry should be examined.

Resistance occurs naturally as a result of bacterial evolution, but human overuse and misuse of antibiotics are known to be major contributors to this process (11). Antibiotic use in animal husbandry, however, has recently been under increased scrutiny as a possible significant source of antibiotic resistance (13). Antibiotics are fed to animals to treat diseases, to promote growth, and to increase feed efficiency. This continuous and extensive use of antibiotics inevitably leads to selection of resistant forms of bacteria. This becomes a larger problem when antibiotic-resistant bacteria and/or residues of antibiotics are passed to humans through consumption of animal products (14). Although the extent to which this occurs or could occur is not known, the transfer of resistance from animals to humans needs to be addressed as it is a possible significant source of antibiotic resistance.

This paper explores how conditions within the beef industry result in antibiotic resistance. Philosophical perspectives underlying the treatment of animals will first be addressed, including Western and non-Western views on animals and where these originate, the process of domestication, and a historical perspective on how disease and antibiotic resistance can arise in animals and spread to humans. After the background of these views has been presented, a brief history of the beef industry will be included to show how certain beliefs about animals underlie its structure. This will be followed by a discussion of how antibiotics are used in the beef industry, how resistance can arise, and how this resistance can spread from animals to humans. Solutions for this growing problem will then be discussed, with emphasis on ways to ameliorate the current treatment of animals in order to improve conditions and decrease the need for antibiotics.

**Philosophical perspectives**

Animals, from the first hunt to the first domestication to the first factory farm, have had varying relationships with humans. These interactions have led to changing views about animals over time and place. In many traditional societies, animals were gods and mystical creatures because of their significance to humans. Animals in the food industry in Western society, however, have dropped to the status of "machines." Human views about animals determine how they are treated in the animal food industry and society as a whole.

Some main sources for current Western views of animals are ancient Greek beliefs, the Christian creation story, modern philosophy, the theory of evolution, and "commonsense" ideas about animals. Ancient Greeks believed essentially that animals were not rational beings and therefore did not possess souls. In the Creation story,

animals were not created in the image of God and were therefore seen as distinct from humans. Rene Descartes, known as the father of modern philosophy, also placed a wide chasm between animals and humans: he is known for his view that animals are mere "automata" without feelings or awareness. (16). The philosophy of the beef industry, as animals are treated as means to produce a finished product at maximum efficiency, seems to resemble that of Descartes.

To Descartes, animals were machines. He stated, "despite appearances to the contrary, they are not aware of anything, neither sights nor sounds, smells nor tastes, heat nor cold; hunger nor thirst, fear nor rage, pleasure nor pain" (17). Animals' behavior, according to Descartes, is simply due to a sensory organ's reaction to stimulation. The animal does not know it is in pain but reacts with a response (yelp) to a stimulus (a thorn). This reaction is one without conscious thought; it is almost like a reflex. His pupils acted on this: "They admit to beating dogs with perfect indifference and making fun of people who pitied them. They also did vivisections in which they nailed animals to boards to study blood flow" (17). Descartes basically thought animals were machines and should be treated as such. He also called the commonsense attribution of consciousness to animals "prejudice from our earliest years." The beef industry, because it is focused on producing a beef product, in most of its practices, treats animals like machinery for the output of this product. This is evident in the manner in which cattle are raised, fattened, and sent to slaughter; each step in the process is completed with maximum efficiency to produce the most product in minimal time. This has lead to a dependence on antibiotics for the production of beef.

A nearly opposite view to that of Descartes is Singer. Singer, in his book Animal Liberation (20), details his ideas that animals, because they can suffer as much as humans, should be treated on equal grounds. Singer believes that if humans do not give animals equal consideration, they are guilty of what he terms "speciesism," or unjustified bias against another species. He also describes conditions at factory farms and feedlots and details the poor sanitation and unnatural environments that exists in some of these In these environments, due to crowding, infrequent cleaning, and artificial conditions, disease can arise and spread easily. In the beef industry, cattle can become sick, incur hoof injuries, etc. in feedlots, which are largely artificial environments created to fatten cattle at maximum efficiency and minimum cost. Singer believes that if conditions and basic treatment of animals within the animal food industry were improved, disease would be decreased, etc. and fewer antibiotics would have to be utilized. The maintenance of healthy animals is a definite goal of the beef industry as healthy animals yield the best product and the most profit. However, the health of beef cattle is still dependent on antibiotic use.

Traditional (indigenous) societies' view of animals is an amalgam, as evidenced by research conducted in Costa Rica (10), between ancient rituals and current Western views brought by outsiders. In hunting and gathering societies, humans depended greatly on animals for the hunt; animals and nature had indomitable control over human survival. Humans in these societies viewed animals as supernatural creatures who had power over humans and even the ability to become human. Before the hunt, in the society of the Tukano Indians in the Amazon, hunters would have to ask the permission of the Vai-mahse, or god of the hunt, in order to perform the kill. If they failed to do so, the god

would punish them by, according to the tribe's beliefs, not returning the soul of the animal so that it would be available for future hunting. Animals also play god-like roles in many of the creation myths of traditional societies. Animals in many traditional societies, then, were seen as god-like beings who could control the fate of humans. In modern Western society in the animal food industry, however, this view has completely reversed; animals are seen as machines to be utilized by humans.

The process of the mechanization of animals began with the domestication of animals. Diamond characterizes this process in his book entitled Guns, Germs, and Steel (3). Domestication is advantageous: "The availability of more consumable calories means more people. Among wild plants and animals, only a small portion are edible to humans. By selecting and growing those species that we can eat, we obtain far more edible calories per acre" (3). Domestication, therefore, yields much more usable energy from animals than hunting and killing them.

How did humans learn to use this advantage? Plant domestication, which Diamond details, provides a parallel for the process in animals. Humans were attracted to certain kinds of plants because of favorable characteristics such as "size, sweetness, fleshiness or seedlessness, oily seeds, and long fibers" (3). This led to humans inadvertently controlling reproduction of these favored plants by spitting out seeds, etc. that grew back around settlements. Humans soon realized that they could intentionally plant crops and select for desirable characteristics.

This process was similar in animals. Animals that had desirable characteristics or did not have certain unfavorable ones (such as meanness) were domesticated, which Diamond defines as "animals selectively bred in captivity and thereby modified from its

wild ancestors, for use by humans who control the animal's breeding and food supply" (3). With animals, however, the possible number of domesticable species was considerably lower than plants. Diamond states that "the importance of domesticated mammals rests on surprisingly few species of big terrestrial herbivores" (3). There were only 14 such animal species domesticated before the 20th century, which have become the major 5 of the world today (sheep, goats, cows, pigs, and horses). The advantages that these species offer and continue to offer, however, were many: "in societies possessing domestic animals, livestock fed more people in four distinct ways, by furnishing meat, milk, and fertilizer and by pulling plows" (3). Although domestication was definitely an essential process and necessary for the current functioning of society, the current animal food industry has become increasingly "mechanized" and the majority of cattle are raised in holding facilities rather than the farm or range. This has advantages and disadvantages; as most aspects of a cow's life are now scientifically controlled, the highest quality beef product can be produced at maximum efficiency. However, this production currently depends on the use of antibiotics.

Despite the advantages associated with domesticated animals, disadvantages also came with the package-- namely disease. In chapter eleven, "The Lethal Gift of Livestock," of his book, Diamond details how epidemic diseases can arise from contact with domesticated animals. "The major killers of humanity throughout our recent history—smallpox, flu, tuberculosis, malaria, plague, measles, and cholera—are infectious diseases that evolved from diseases of animals" (3). The origin of an epidemic, according to Diamond, has several steps: a disease is passed from animal to human (zoonotic), the disease causes a brief epidemic that dies out, the disease become a

permanent human pathogen, and the disease finally does cause epidemics. He explains that agriculture facilitates the spread of microbes from animals, cattle in particular, to humans: "This transfer is not surprising considering that many farmers live and sleep close to cows and their feces, urine, breath, sores, and blood. Our intimacy with cattle has been going on for the 9000 years since we domesticated them" (3). "Farmers are sedentary and live amid their own sewage, thus providing microbes with a short path from one person's body into drinking water supplies. Farmers also spread urine and feces as fertilizer" (3). Diamond also describes the "evolutionary battle" that goes on between microbes and humans—"We and our pathogens are now locked in an escalating evolutionary contest, with the death of one contestant the price of defeat, and with natural selection playing the role of umpire." Domestication brought advantages and disadvantages—it allowed humans to obtain resources much more easily from animals, but along with this benefit came increased exposure to disease. This disease risk is currently somewhat controlled by antibiotics, but this method needs to be ameliorated as antibiotic resistance becomes an increasing threat.

**Scientific perspectives**

The beef industry is one of the most highly regulated and controversial enterprises in history; it has been heavily scrutinized and portrayed badly, as in Upton Sinclair's The Jungle. It has developed from the days of local butchers to a national, big-dollar enterprise. Cattle have traveled from small farms to the range to feedlots.

The beef industry began to become a coordinated large industry as livestock raisers during the 17$^{th}$ century led the way to new western frontiers in search of grass, which led to geographical separation between raisers from butchers and processors. The

means of moving cattle has since changed from the trail to water to railroad (21). The cheapest, fastest way to transport cattle remains a goal of the beef industry.

After the Civil War, as cheap Texas cattle became available, the "age of sagebrush" and cattle ranching began in which a large number of cattle were produced on large ranches. Although ranching was more common during this era, it has never really been a significant source of beef; smaller farmers and feedlots have historically produced far more beef. During the 1880's, cattle and land prices changed, resulting in ranchers selling most of their land to smaller farmers. This ended the era fixed in American lore ("Home on the Range") that never actually contributed much to the overall functioning of the beef industry. Cattle today spend much more time on the feedlot than the fabled "range" (22).

The practice of feeding cattle commercially (feedlots) was around as early as 1690 and by 1840 was common throughout the Midwest corn belt. Feedlots in their current form appeared around the 1960's; cattle in feedlots are fed high-energy grains so that they gain weight as quickly as possible for slaughter (21). Meatpacking began with small-town butchering but has developed into large corporations that are highly government-regulated and have been described as near-monopolies (22).

The old "flow" of beef was from multiple livestock raisers to a few feedlots to multiple meatpacking plants to buyers (supermarkets that butchered the cattle) to the consumer (21). The most recent trend, however, has been for packing plants to move from cities closer to feedlots; this means costs of transporting cattle are reduced. Also, these plants produce "boxed beef" that is already processed and ready for the consumer; this eliminates the need for a supermarket butcher and for processing.

Along with this increased efficiency of the process of beef production came changes in health and safety standards. Meat from small-town butchers was not always safe; earlier butchers did not know how to inspect meat for microbial contamination (this is how tuberculosis could be spread). Conditions within the beef industry's meat-packing plants were exposed, some say exaggerated, by Upton Sinclair's The Jungle. Safety standards have definitely become more regulated and enforced since the days of the early butchers and even since The Jungle; the beef industry is now highly regulated (21). However, conditions are still such that it is dependent upon antibiotics to function.

Use of antibiotics in the beef industry becomes a problem when resistance arises, which then can be passed from beef cattle to humans. Antibiotics are used to keep animals healthy and promote growth before cattle reach slaughter (13). These antibiotics are often used too indiscriminately; this results in antibiotic resistance. This resistance can then be passed from animals to humans through several routes (11). Antibiotic resistance stemming from the animal food industry has received increasing scrutiny as a possible significant source of resistance. As resistance in general is on the rise, it is a source that cannot be overlooked.

In North America and Europe, it is estimated that about fifty percent (in tonnage) of all antimicrobial production is used in food-producing animals and poultry (4). There are three principal modes of antibiotic use in food-producing animals, prophylaxis, treatment, and growth production. Overall, the largest quantities of antimicrobials are used as a regular supplement for prophylaxis or growth promotion (subtherapeutic, mechanism is unknown) in the feed of animal herds and poultry flocks. Treatment levels of antibiotics are given for recognized disease. Increased intensity of meat production

depends on antibiotics; "current intensive animal production systems depend on antibiotics" (1).

Resistance arises in animals when subtherapeutic or prophylactic use results in exposure of a large number of animals that are mostly not sick to antibiotics; this is clearly different from human medicine, where decisions for therapy are made on an individual basis. Subtherapeutic use, because it is consistent, alters the gut flora of exposed animals such that they frequently contain resistant bacteria (12).

Also, inadequate understanding and training among farmers, veterinary prescribers, and dispensers about the effects of inappropriate antimicrobial use on resistance and of appropriate usage guidelines are common (14). Inefficient and inadequately enforced regulatory mechanisms regarding antibiotic supply also contribute to misuse and overuse. Discrepancies between regulatory requirements and prescribing/dispensing realities are often worse than in human medicine (13). Also, growth promoters are generally not even considered drugs and are either not licensed or licensed solely as feed additives (14). In some settings, poor manufacturing quality assurance results in the supply of sub-standard drugs. These drugs are also marketed; practices by private industry influence prescribing patterns of veterinarians, feed producers, and farmers (23).

Resistance that arises because of the above practices can be transferred from animals to humans in several ways. Consumption of animal products can transfer actual bacteria as well as antibiotic residues, which are "low levels of the drug and its metabolites which remain in the animal carcass or other food products of animal origin after drug administration has ceased" (11). Resistant bacteria/residues can also travel

through reservoirs, including effluents from farms and the use of farm waste as fertilizer, feed supplement, or bedding. Antibiotics may also not be destroyed in treatment of waste-water from animal industry and thus persist in soils. These avenues can lead to antibiotic residues selecting for resistance in the human gut-flora, direct transfer of resistant bacteria from animals to the human gut, and transfer of resistance genes (transformation) from resistant bacteria of animals to the human gut-flora (24).

The transfer of resistance from animals to humans through these paths is a growing problem because these lead to increased resistance in general, new resistance, cross-resistance and horizontal gene transfer. The transfer of resistance can also result in increased pathogen load—"the number of resistance genes carried but not expressed" (12).

All this could also pose a threat to human health. Although "most scientists agree that the increase of bacterial resistance to antibiotics in humans is largely the result of overuse of antibiotics in human medicine" (13) and "it is estimated that as little as ten percent of the problems of drug-resistant pathogens in humans originate in livestock health practices" (12), "increasingly, data suggests that inappropriate antibiotic use is posing an emerging public health risk and studies show the connection between animals and humans" (5). Also, "studies tracing animal sources for human infection by drug-resistant pathogens do exist and are growing in number" (14). There is also direct evidence that resistance does pass from animals to humans. The Food and Drug Administration (FDA)-conducted risk assessment on flouroquinolones and *Campylobacter* revealed that "the use of flouroquinolones in poultry causes the development of fluoroquinolone-resistant *Campylobacter* in poultry, that this resistance is

transferred to humans and is a significant cause of resistant infections and humans, and that these resistant infections are a hazard to human health" (7). Also, it has been suggested that because resistance to a new human drug Synercid seemed to appear so quickly, this resistance may have come from an animal drug, virginiamycin, that has been in use for years as a growth promoter (15). Although the amount of resistance arising from the animal food industry is not certain, the fact that it is a possible significant source of resistance definitely merits an effort to reduce resistance.

Current efforts to monitor and reduce resistance within the beef industry and the animal food industry in general include programs to report resistance, prudent use guidelines and recommendations, educational efforts, research and study on resistance, and the elimination of antibiotic use. The National Antimicrobial Monitoring System (NARMS) serves to "monitor resistance in human enteric bacteria" (8). Judicious Use Guidelines produced by the FDA and other agencies "emphasize preventive actions to avoid disease, suggest other options before choosing to use antimicrobials, and propose the use of drugs, when possible, that are less important to human and animal needs" (6). The World Health Organization (WHO) has also produced guidelines (23) which emphasized obligatory prescriptions and included recommendations for veterinarians. The FDA is conducting risk assessments and other research to determine how big a problem antibiotic resistance within the animal food industry really is. Efforts are being made to deal with resistance within the animal food industry, but further steps should be taken in the future, especially concerning treatment of animals within the industry.

Future steps should include studies to elucidate mechanisms of resistance within the human gut and research on environmental bacteria's capacity to degrade antibiotics,

as information from these areas is currently lacking. The economic/medical consequences of a reduction in antibiotic use should be investigated. Education efforts and public awareness campaigns such as the Alliance for the Prudent Use of Antibiotics (APUA) (2) should be continued and augmented. Current efforts should be carried on and the above steps also brought out as weapons in the fight against resistance.

Animals in Western society currently occupy a role far from the god-like creatures of traditional societies; animals in the beef industry and the animal food industry in general are seen as machines to produce a product. Every aspect of their life before they become a "product" has been designed for maximum efficiency at minimum cost. This efficiency currently depends on antibiotic use for growth promotion as well as treatment and prevention of disease. As antibiotic resistance is a growing problem, efforts should be made to reduce the amount of antibiotics used in the beef industry, to prevent the development of future resistance, and to prevent the transfer of this resistance from animals to humans. Research and efforts into altering the conditions under which animals are currently raised so that they require fewer antibiotics should be a priority. This would include determining how feeds can produce the desired weight gain without the use of growth promoters, how health of cattle could be maintained with a reduction in the use of antibiotics (by improving conditions in feedlots, etc. and further raising health standards), and how this reduction in antibiotics would affect the industry on the economic level. As Singer states, "A much more detailed understanding of the animals' psychological and physiological requirements (while also considering economic controls) would lead to greater returns" (20).

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