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Ready for the Robot: Bovines in the Integrated Circuit

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Introduction. A typical cow on Earth at the turn of the 21st century is figured as an information-generating machine. She generates data from the time she is born, at every developmental milestone, with the birth, growth, and death of each of her calves, including birth, weaning, and yearling weight, calving ease, and feeding data that help farmers compute efficiency and make breeding and slaughtering decisions. If she is a milk cow, data are kept every time she goes to the milking parlor to be milked. She may leave traces each time she leaves the farm, if she travels across state lines, or is sold or slaughtered. The data she produces are the basis for novel technologies that purport to increase simultaneously the agency and the productivity of cows. In this paper, I consider contemporary cattle breeding practices in light of developments in farm automation and Donna Haraway's cyborg figure.

Haraway identifies the appearance of cyborgs in cultural production at a historical moment when shifts in global capital replace "comfortable old hierarchical dominations" with "scary new networks" she calls "the Informatics of Domination" ("Cyborg Manifesto" 161). In this essay, I describe an informatic feedback loop whose output is the Domination of Informatics, which condenses on both humans and cattle along power nodes called DNA and data, unmaking and remaking gender and labor in frightening ways that also carry the germ of other possibilities. I consider the cyborg as a figure that breeches bovine-human boundaries as well as bovine-machine boundaries, in order to think about possibilities for making new demands on animal sciences for resistant knowledges for cowborg survival.

I trace the predicament of cattle in high tech, particularly dairy cattle, to think through feminist commitments to non-human animals whose exploitation is enhanced through sexual divisions of labor, through gender made and unmade by capital, and to think about alliances with farming animals made through the social relations of science and technology, even if our experiences of it are asymmetrical. Cowborg politics have a seed of companion species in the code. Cowborgs are assembled from bovines, humans, machines, codes, algorithms, gametes, cryopreservation technologies, harnesses, plows, and stories, through pedigree practices that graft cows and humans into the same cyborg litter: cyborgs are "imploded entities, dense material semiotic 'things' — articulated string figures of ontologically heterogeneous, historically situated, materially rich, virally proliferating relatings of particular sorts, not all the time

everywhere, but here, there, and in between, with consequences" (Haraway, *Staying with the Trouble* 104). Cyborg politics allow a query into the features of bovine life without technological determinism or unqualified re-imposition of the human-animal and other divides. Because, like the cyborg, the cowborg is impure, heretical, non-innocent, she has no originary history to return to. There is no back breeding to some cow whose life is not entangled with human culture, no extraction of genes for lactase persistence from the human genomes in which they appear, no unwinding of humans from the lives of cows. Domestic cattle and humans must, for at least the near future, remain yoked together.

In particular, the association among technologis, cows, and people is articulated and contested through the meanings and discourses about genetics, value, and breeding that are crucial to the pedigree practices that structure cattle breeding. Mutating breeding practices seem to be shifting from the prestige of noble cow families to emphasis on quantified traits in EPDs and sire summaries. I discuss the ways these statistical summaries work hand in hand with ARTs and discourses in the service of breeding. Statistical analysis, modeling, and the quantification of lucrative traits have led to the development of means for clustering traits in parallel to breed, pointing a way to de-emphasizing "breed" as a proxy category, in favor of the desired traits themselves.

In what follows, I reflect on the possibilities for responding to bovines in human-bovine companionship through the affordances of automatic milking systems (AMS) and farm automation. As laborers, cows suffer dramatic pressures on productivity that are manifested genetically, in their own bodies, while data-greedy robotic milkers generate new knowledge for human manipulation of bovine genomes. One alluring but catastrophic scenario for addressing cowy suffering would be to end dairying absolutely, ending both domestic cattle and some non-capitalist lifeways of people in companionship with *Bos* kin altogether. Another is to dream Haraway's ironic dream of a common language, to embrace, in our alliances with cattle, the heteroglossia she describes in the Cyborg Manifesto.

The Automated Pastoral. The Pasture Dairy Center at Michigan State University has two automatic milking systems for its resident dairy herd, along with a series of robotically controlled paddocks. Located at Kellogg Biological Station, the research station of the historical land grant agricultural university, the dairy anticipates visitors. The robots are positioned at the short end of a long pole barn, where visitors can view the human "interface" for the AMS through large glass windows. Visible are the hinge of the robotic milking arm, the hoses and milk tank, an emergency stop button, and a

small touch screen control panel. A gap allows the robotic arm access into a chute where a cow will attend to be milked. The cow "interface" of the robot inside the barn involves a few fence panels constructed into a lane where the cows can line up to wait their turn at the robot. A video monitor is mounted inside the viewing room, showing the cows queuing in the barn in real time.

On my visit, some six or seven cows are waiting for their turn placidly, if somewhat restlessly. The robot turns a cow out of the chute and begins its cleaning cycle, rinsing the milkers, hoses, and tank with clean water. On the cow side, the robot has opened the other end of the chute and I can see a cow's hooves through the short gap near the floor. She enters slowly, puts her head down to look through the gap and inspect the chute, turning her head side to side as she moves to compensate her poor near sight and to enable her to perceive the depth of the enclosure. She has positioned her body in the chute and, though I now see only her hooves and udder, I know she is receiving a nutrient dense ration from a bowl dispenser in the robot housing.

The robot recognizes her by her RFID collar and begins moving. The arm, neither swiftly nor slowly, moves down low near the ground, centered between the cow's fore and hind legs, then shifts up and back toward her udder. The cow shifts too. She seems to settle on a wide stance that will oblige the robot and be comfortable for a few minutes of milking. At the first touch of the cleaning brushes, she lifts a hind hoof and then settles again for the cleaning phase. A spray of water I'm told is warm and a soft rotary brush clean her teats, taking just a few seconds. Then, with laser sights, the robot attaches the four milkers, one by one, to her teats. Almost immediately, milk can be seen pulsing through the hoses to the tank. The cow has settled and she is done in just a few minutes. The robot opens the chute at the other end and she leaves to rejoin the herd.

In the barn, many members of the herd are lined up shoulder to shoulder, eating fodder being fed out in a long trough with metal stanchions. A large pressure-activated rotary brush affixed to a pole is being used by a cow to receive a back scratch. One cow refuses my offered ear scratch so I give it to another. At the end opposite of the barn, access to the paddocks is controlled by a robot and activated by each cow's RFID tags to allow intensive management of the pasture. As a group of visitors walks along the line of cows steadily eating at the feeder, none seem perturbed. With alertness trained by a childhood on a cattle ranch, the cows seem calm and unbothered to me.

Cyborg figure, cyborg politics. What are we to make of the contrast between the pastoral and the high tech, spattered manure and freshly cleaned milk tank, placid cows amid busy robots in the scene at the Pasture Dairy Center, or other AMS-based dairies like it? Behind the scenes, an assemblage of sensor technologies, miniaturized electronics, robotics, genomic technologies and discourses, networking protocols, cloud computing, cryopreservation, and data science, along with subsidies, tariffs, and farm lending programs, are at play. Haraway uses "social relations of science and technology" to describe a "historical system depending upon structured relations among people" ("Cyborg Manifesto" 165). Her cyborg figure, now more than 30 years old and part of her queer litter, deep in "the trouble" with her more recent analytic, companion species (Haraway, *Staying with the Trouble* 105), is still productive for thinking about the three divides she identified when the Manifesto was first published in *Socialist Review*.

In "A Cyborg Manifesto," Haraway describes three "boundary breakdowns" or "leaky distinctions," including between humans and non-human animals, between organisms and machines, and between the physical and non-physical (152-153) that characterize the late 20th century. Haraway adopts the figure of the cyborg as a way to work through productive complications for socialist-feminist politics in a historical moment when binary categories are no longer stable, natural, or self-evident. The cyborg "appears in myth precisely where the boundary between human and animal is transgressed" (154). Cyborgs are part animal, part machine, and they not only deconstruct borders and binaries, but warp categories and pleasurably breech them.

This breeching poses a problem for socialist politics because familiar analytics of labor, the family, and the home are reworked. And crucially, the foundations of some strains of radical feminism on essentialist definitions of the category "woman" collapse without the structural support of these categories, taking along with them claims for privileged knowledge and identity staked on the experience of oppression. For Haraway, affinity, rather than identity, is the animating feature of political coalitions. The cyborg figure emphasizes the constructed, historically located, and stitched-together quality of all unities, while avoiding the erasure of difference intrinsic to the universalizing "white women's movement" Haraway criticizes (156).

Haraway scrupulously avoids attaching purely positive valences to the cyborg, but invites a politics in which feminists take stock and account for knowledge practices as they grapple with the social relations of science and technology. Haraway proposes a socialist-feminist response to late 20th century economic, technological, and scientific

conditions she calls the Informatics of Domination, which she describes as "a massive intensification of insecurity and cultural impoverishment, with common failure of subsistence networks for the most vulnerable" (172). Information and information technologies are, of course, crucial features of these "rearrangements of world-wide social relations" (161), in which "the translation of the world into a problem of coding" is most visible in communications and biotechnologies (164). Rejecting technological determinism, Haraway invites readers to engage the cyborg figure as "the self feminists must code" (163).

Informatics of Domination might be too mild a term to describe bovine lives, simultaneously tightly circumscribed by turbo-charged breeding practices (Orland), while extended the appearance of new kinds of agency in dairy operations as affordances of automatic milking systems. The Informatics of Domination has mutated into Domination of Informatics, not just for cows but for all of Earth's systems, which are now covered in sensor and satellite networks, infrastructures for monitoring and surveillance submerged even in the most remote of locations. But the cyborg is a figure of resistance and refusal against technological determinism. The essentialisms that accompany these familiar structures of domination don't compute for cyborgs. As Haraway argues, "the need for unity for people trying to resist world-wide intensification of domination has never been more acute. But a slightly perverse shift of perspective might better enable us to contest for meanings, as well as for other forms of power and pleasure in technologically mediated societies" (154). While the cyborg is non-innocent, partially spawned of partnerships between science and militarism, it is also an apt companion for thinking about the predicament of bovines in high tech: "From another perspective, a cyborg world might be about lived social and bodily realities in which people are not afraid of their joint kinship with animals and machines, not afraid of permanently partial identities and contradictory standpoints" (154).

Bovines in the Integrated Circuit. Haraway's metaphor of the integrated circuit references Rachael Grossman's ethnographic work in the global semiconductor sector, in order "to name a situation of women in a world so intimately structured through the social relations of science and technology" (165). In Grossman's analysis, semiconductor manufacturing is "literally a global assembly line stretching more than halfway around the world" (33). Firms "developed a whole battery of methods to manipulate and control the women who work in their plants.... [T]hese techniques specifically exploit the traditionally defined attributes of femininity" (30). As Grossman notes, "The sudden concentration of women in advanced industrial enclaves might well be expected to foster the emergence of a strong feminist consciousness among them. The carefully

planned personnel policies work against this" (30). In the words of an Intel personnel officer, "We hire girls because they have less energy, are more disciplined, and are easier to control" (29).

Semiconductor manufacturing is precision work that requires fine motor skills, significant eye-hand coordination, and highly attuned proprioception. Asian women were described by manufacturers and government labor departments as being naturally and uniquely suited to this work, which takes a toll on workers' eyes and health and is remunerated at barely livable rates. Haraway links women through the "enforced attention to the small" from the "nimble fingers of 'Oriental' women" to "the old fascination of little Anglo-Saxon Victorian girls with doll's houses" (154). Women in the integrated circuit are soldered into the circuits of global capital, manufacturing electronics components shoulder to shoulder with women in other countries and factories who work on a different stage in the manufacturing process. This highly exploited, disposable, and gendered labor force makes high tech possible.

I draw on Haraway and Grossman to highlight the gendered and increasingly high tech work of cattle, particularly dairy cattle working in industrial settings, and to situate cows in the social relations of science and technology. Cows' work is often invisible "except when the cows resisted or refused to collaborate, precisely because this resistance showed that, when all is functioning well, it is because of an active investment on the part of the cows" (Despret, *What Would Animals Say* 180, describing Porcher and Schmitt). From pulling plows, carts, and wagons to "getting groceries" (grazing) it is obvious to those who labor with cattle that they work, even if that is only belied in complaints when a cow is "lazy" and must be "retrieved" for milking. But other work of cattle is invisible, gendered, and breed specific. A cow chewing her cud in the shade might seem to be on her lunch break, but she's engaging in both productive and reproductive labor, making milk and reproducing her labor power.

As Porcher and Schmitt describe, dairy work relies on the active collaboration of cows, who "invest their intelligence and their affects in the work" (55). While the specific acts of collaboration vary across the job sites of domestic cattle, dairies are not unique in this regard. The labor of oxen pulling a plow may be obvious, whereas making milk may not appear as work because it is not clear that dairy cows have a subjective relationship to lactation. As with the gendered labor of care, making milk is presumed to be a natural response on the part of dairy cows' bodies. We understand that fashion models move their bodies in particular ways, respond to directions from handlers and photographers, but that the shapes of their bodies and faces are part of what they

produce. Their physical appearance seems to emanate naturally from their bodies and is supported by their cooperation and collaboration. The work of domestic cattle is structured by gendered divisions of labor, as their work making what appears to issue naturally from their bodies requires collaboration of multiple kinds. Increasingly, not just milk but also data are made by bovine bodies.

Domestic cattle perform many kinds of labor on farms and ranches, with sharp divisions of labor according to the sex and reproductive status of the cows, as well as their breeds. On cattle ranches, most bull calves will be castrated to avoid growth in bone mass, and raised as steers. Their work is to gain muscle and not so much bone as they grow, and to stay calm and gentle. Some will be raised as veal calves. Bulls castrated as adults will be gentle and strong, necessary traits for their work as draft animals. Some bulls work as teaser bulls to identify cows in estrus. These bulls are sterilized but not castrated and some, called "sidewinders," have been altered surgically to direct the penis to the side of the body to prevent intercourse. A cow otherwise identified for culling can also work as a teaser animal if she is treated with hormones to encourage mounting behavior.

Purebred bulls "in service" are consorts to cow herds, usually beef cattle, at a recommended rate of approximately one bull per 20 to 30 cows, depending on the age of the bull, his libido, and his social status in the herd. Bulls of beef breeds may also work at studs as AI sires, if they are purebred bulls with strong performance traits as measured through "expected progeny differences" (EPDs) or "expected breeding value" calculations (EBVs). Since most dairy cows in the US are impregnated through AI (around 95%), purebred dairy bulls are unlikely to mingle with cows. Their work is to produce semen to pass along traits needed by their daughters for successful work in a dairy, and to cooperate with handlers at the stud in the collection of their semen. Bulls may be kept in isolation to eliminate chances of sexually transmitted infections. Dairy breed semen is often sex sorted, since the aim, typically, is more daughters to add to the milking herd.

Cows in a "cow-calf operation" on beef ranches give birth to heifers and bull calves and raise them as "animal units." These cows' mothering and milking ability is prized. Some heifers will be "replacement" heifers and stay in the herd as older, sick, or under-performing cows are culled and slaughtered. A beef cow's job is not just to bear calves but to raise them, to demonstrate good "mothering ability" so that she calves easily and protects her calves on the range, and so that they have a good weaning weight when they are separated from her.

But not all cows gestate or raise calves. Some work as embryo donors. With hyperovulation synthetically induced, a donor cow is inseminated with sperm from a high performing sire. Some five to seven days later, the resulting embryos will be retrieved from her uterus through a process called flushing. The embryos, perhaps as many as 20, are graded under a microscope, then frozen or implanted in another cow whose estrus has been synchronized. After being administered a hormonal abortifacient, the cow can hyperovulate and fertilize ova again at her next estrus.

Dairy cows do not need to be good mothers because their work is incompatible with raising their calves, who are taken away soon after birth. Instead, dairy cows must make good milk and plenty of it. But that is not enough to do their work well. They must also eat continuously to keep up with the enormous energy expenditure of high-yielding lactation. They must not burn calories doing unnecessary walking. They must rest lying down to chew their cud and make milk. They must come to be milked at the right time and insist on taking their turn at the robot and at the feeder. And dairy cows must be docile, under penalty of death.

Dairy cows are "an ultraflexible underproletariat, exploitable and destructible at will" (Porcher and Schmitt, 42), and the fact that they labor is assumed in the marketing and animal sciences literature. Dairy cows have "time budgets" to allocate across milk-making activities. "In an ideal robotic world, there are three groups of animals: cows at the feeder, cows laying down and cows standing at the robot" (Caron, "For a Successful Use of Milking Robots" 14). Cows need 10-12 hours of time lying down (Westin et al.; Helmreich et al. 319-20) during which they rest, ruminate, and make milk. They must get up to attend the milking robot frequently enough to avoid pressure in their udders and mastitis, but not so frequently as to impede the ability of other cows to operate the robot, or to cut into eating and lying time. While waiting may be as short as 25 minutes on average (Helmreich et al. 318), it could be as long as 7 hours for cows of low social rank "in crowded situations (i.e., where all cows have to pass through the robot to access pasture)" (Westin et al. 559). Thus, cows with lower rank or higher milking needs will spend more time queuing and less time resting or eating (552). Social competition can result in displacement that reduces lying time or shortens the duration of bouts (559). Cows with high milking frequency spend more time at night waiting for the chance to use the robot, which in turn means shorter bouts of lying time (Helmreich et al. 321). One study of the relationship between injuries and lying time in AMS dairies reported that only half of focal cows were uninjured, that is, neither lame nor having lesions on the hocks or knees that are associated with hard flooring and bedding, and

which appears as a problem because it results in decreased visits to the robot (Westin et al. 555). Researchers were skeptical, however, that decreased lying time resulted in reduced welfare (Helmreich et al. 321), insofar as they could detect a difference in welfare.

While using the milk robot is described as "voluntary," it is analogous to voluntary human labor under capitalism. Strategies enforcing visits to the robot may be required so as to reduce human labor spent retrieving cows for milking. These may include offering supplemental feeding in a pen that cows can only access after attending the robot (Scott et al. 62). Cows working in AMS dairies have a partial preference for indoor housing that is likely influenced by the need to remain close to rations to meet the energy requirements of high production. Thus, "lower yielding cows may have had more time available to graze, whereas the high yielding cows may have needed to use their available eating time consuming TMR [total mixed ration] to meet their nutritional requirements" (Charlton et al. 8). Cows in the contemporary social relations of science and technology are so constrained by their genetic need for energy to produce milk, on the one hand, and selection for docility, on the other, that it is not possible to genuinely say they have freedom or choice. In the analysis of Holloway et al., "cows' freedom, choice and subjectivity is subordinated to the need to use the robotic technology efficiently and constantly" ("Recapturing Bovine Life" 138). They are free, in Marx's words, to work or to starve, with attendant life-threatening ketosis, or to be culled.

Domination of Informatics. "Women in the integrated circuit" names "the situations of women in a world so intimately structured through the social relations of science and technology" (Haraway, "Cyborg Manifesto" 165). The predicament of cattle is no less structured through these relations and even more intimately so. In contrast to the pastoral landscapes inhabited by cows in our collective imaginations, cows have been part of high tech for some time. Cryopreservation techniques were pioneered with cow gametes in the 1940s. Statistical prediction of progeny traits has developed with increasing power alongside breed improvement efforts and animal science through the 20th century. The Informatics of Domination is not only a description of the social worlds of humans.

In all the work that cows do, they generate data: the acts of being born, weaned, or slaughtered, siring or giving birth to a calf, lactating, ovulating, or ejaculating, can potentially generate data that in turn shape the contexts in which cows work, including their own bodies. Record keeping practices yoked with reproductive technologies, genomic testing, statistical analysis, and the rhetorical power of animals, organized

under the sign of the pedigree chart, fuel complex feedback loops and robust statistical likelihoods, treated as predictions of bovine performance traits (Calvert).

The information infrastructures needed for the cow to generate the data that power these predictive algorithms have been a couple hundred years in the making. Barbara Orland traced the development of measurements and processes for standardization of dairy cow bodies, including keeping milk records, animal measurements, and pedigree charts. Showing how these practices were established by the early 20th century, Orland demonstrates that "[c]ollecting data about milk performance is itself part of the history of improving the cow's natural capacity to lactate" (168). According to Orland, "today's high-yielding cow came into being within a new culture of competition, standardization, performance control, selection, and predictability" (184).

These statistical predictions are used in breeding decisions and gamete selection, and are part of the tangled loop of ARTs and information technologies that organize life for cattle in countries of nearly every economic status. Cows and bulls both toil as gamete producers, sometimes in addition to their work making milk, raising calves, or making meat. Far from the bucolic scene of the pasture, many cows live in cow sheds without access to pasture, in veal crates that constrict their movements while keeping them socially isolated, or in crowded, dusty, or muddy "concentrated animal feeding operations" or CAFOs. While many cows around the world are free to graze, move around, and otherwise fully behave as cows, many more do not. So, like Haraway, I think here about the situation of cows in the social relations of science and technology.

EPDs and sire summaries are charts of statistical calculations of commercially valuable traits of a registered bull or cow's offspring that evolved from pedigrees through the practices described by Orland, via breed improvement programs in the early 20th century as breeders increased the number of traits they measured and compiled. Measurement data of a given animal's progeny are computationally compared with all other animals in the breed database, and then assigned an index and accuracy score. As artificial insemination and cryopreservation became both technically possible and approved in the bylaws governing registration in purebred herd books, the number of progeny a bull could sire vastly increased, which in turn increased the number of observations of performance traits in his offspring. This, in turn, enhanced the power of the statistical predictions. These breed databases of phenotypes and biological relations are crucial resources for the development of genetic trait analysis. Since the sequencing of the bovine genome (with L1 Dominette 01449, a Hereford cow, standing in as a reference for all *Bos taurus*) in 2009, bovine genetic testing has expanded rapidly and

EPDs and performance summaries are now "genomically enhanced" to influence accuracy scores for animals with fewer progeny. These tables now typically accompany pedigree charts for purebred animals. However, in some instances, pedigree charts are omitted or decentered and emphasis is placed on the scores for given traits. Holloway and Morris describe the "boosted bodies" of cattle represented such that a cow "isn't simply a body, but a body *and its data*" (1718).

Statistical evaluation with genomically enhanced accuracy scoring is promoted to farmers as the ability to breed cows with laser sights on specific, abstracted, traits, targeting the performance of the herds as a whole, for example, calving ease, weaning weight, or docility, and thus address perceived weaknesses through the next calf crop. EPDs and EBVs are key artifacts for understanding bovine-human relations in the 21st century. They are possible only because of the development of ARTs, computational power, genetic discourses, and genomic technologies.

Orland's turbo cow has mutated into a what DeLeval calls a "robot cow" (Wadsworth) or a dairy cow who has internalized the habits and temperament necessary, and who is genomically shaped, for working in automatic milking systems. AMS are more than milking machines. The collars the cows wear let the AMS know their identities and the robot captures and stores data produced through the cows' lactation work. The quantity and quality of the cows' milk is noted; their estrus can be detected; mastitis and other health issues related to productivity can also be discovered with in-line sensors. The milk can be automatically quarantined based on the analysis. If a cow has mastitis or is being treated with antibiotics, her milk can automatically be discarded. When a cow is being milked, she generates other data as well: the speed at which she lets her milk drop and milk out, and the frequency of her visits. As Holloway et al. demonstrate, these "data become part of a metrological regime which can be used to make decisions on what interventions in the life of each cow are necessary" ("Re-capturing Bovine Life" 137). The milking data are added to a cow's performance data and feed back into the performance data of the herd and of her forebears: the talents of the daughter are ascribed to her sire. As the data becomes part of each cow's informatic profile, they iterate through a cybernetic loop with high potential for creating a nightmare situation for cows. These data feed into the algorithmic prediction of genetic traits that encourages the selection of these traits in breeding decisions, emphasizing productivity and docility, and forcing a change in "the parameters of interaction" for both dairy cows and farmers in response (Coppin 49).

Programmable Cows. Marketing materials from manufacturers of milk robots like the Lely Astronaut or DeLeval VMS (Voluntary Milking System) emphasize the freedom dairy cows have in AMS dairies, with positive potential for animal welfare. True, AMS enable cows to choose when they'd like to be milked, but within a matrix of constraints: robot to cow ratio, herd social hierarchy, hours of the day, time pressures for other aspects of dairy work (eating, resting, and ruminating), and the spatiality (Holloway et al, "Re-capturing Bovine Life" 139) of the dairy. Farmers use a variety of techniques to ensure that cows attend the robot with regularity, for example, through the use of one-way gates or by positioning the most nutritious rations in an area beyond the AMS pen (Scott et al.). Since only one cow may operate the robot at a time, stocking capacity and farm productivity depends on cows' cooperation with optimum milking routines.

Cows initiate the milking process by entering the parlor at a time of their partial choice, vying for position with their mates. When a cow enters the stall, she is given a ration of nutrient dense feed to help support the caloric needs of intensive lactation and as a food bribe to entice her to enter the robot. The robot reads the radio tag on her collar and uses previously stored information, along with lasers, to automatically clean her udders and attach milking nozzles.

For robots to be able to work with cows, cows' bodies have to be configured such that the robot can find and attach the milkers. Their udders must be uniform, with teats neither too long nor too short, nor too far from the herd average, and centered near the bottom of the udder. Their hooves must be sound to resist lameness from the concrete flooring of dairy barns, and their legs spaced so that the robot gets "a good rear leg view" (Caron, *Five Criteria*). Additionally, for cows to work with robots, they have to have a calm temperament so that they can wait patiently without moving or shifting, while the robot cleans their udders and attaches the milkers. They have to be sufficiently motivated by the food reward to enter the robot's chute, and they have to go willingly to be milked so that farmers don't expend their valuable labor retrieving them for milking.

To create such cows, prospective semen buyers can choose bulls whose traits complement those already in the herd or choose a match for a particular cow from a large number of bulls in a catalog. Some of these traits are for fertility and feed efficiency, others relate to the physical stature and shape of the bull and his offspring. Other traits relate to the features of his daughters: their pregnancy and stillbirth rates, calving ease, udder qualities and teat placement. The gene for the presence of kinds of milk proteins is also available for selection. Other dairy specific scores include somatic

cell score, mastitis resistance, milking speed, calving ability, metabolic disease resistance, and milking temperament.

The ability to identify and genetically influence so many aspects of a cow's body and correlate these traits to performance has allowed breeders to identify and select traits to influence herd productivity. These information technologies conjoined with assisted reproductive technologies now allow breeders and studs to pinpoint ways cow bodies may be less than ideal for robots, and attempt to reshape them. These traits are already tracked on dairy EPDs. While breed remains an important proxy indicator of genetics, Semex has adopted a strategy that extends genetics discourses in new ways. The company markets semen with highly sought-after clusters of traits: Repromix, Genomax, Immunity+, Sexxed, and Showtime, are a few. These categorize semen by the breeding values for clusters of traits directly, rather than allowing a prizewinning bull or notable cow family to imply those traits. Emphasis has shifted from pedigrees to sire summaries, from breed to breeding values.

Animals who perform well on all of the robot-friendly indices can be grouped together for marketing purposes, as Semex does with its trademark "Robot Ready," a stud book of bulls of different breeds which it has identified as creating daughters whose bodies will conform to the robot. Here, temperament is of particular interest. Cows who work with a robot must have an aptitude for cooperating calmly with it. However, these cows must not be so passive when it comes to reproductive labor. Semex codes for "calm cows at the robot milker and aggressive ones at the feeder: not stressed cows that hold in their milk and try to pass between two stalls when they encounter another individual" (Caron, Five Criteria). An animal welfare concern thus beckons a genetic solution.

Cattle in High Tech Predicaments: Dream of a Cowborg Language. Prize winning pure-bred animals reflect elite values, including dignity and good breeding, back on their owners (Ritvo). These "rhetorical animals" still play this role in purebred sales literature, particularly for beef breeds. But cows have other rhetorical uses as well. While a particular animal may reflect on an owner or breeder, kine as a kind carry other potent meanings for humans — from the compassionate and life-giving Cow of Plenty who appears in Irish, Hindu, and Buddhist traditions, to the ancient aurochs carrying ethno-nationalist meanings in Europe (Driessen and Lorimer). For rural and urban people alike, cows also stand for something beguilingly bucolic. Some farmers' resistance to industrializing dairies is the sense that the public wants to see cows grazing, which sustains a positive valence for dairy products (Holloway et al, "Robotic

Milking Technologies" 193). Indeed, the notion of ancient, plodding farm animals in high tech predicaments is an oddity and a source of amusement and intrigue for tech marketers as well as media theorists. The Critical Media Lab's 2009 project connecting cows to the Internet of Things to enable their tweeting still has a cutting edge feel despite a website showing its age. As if to answer, Microsoft has its own TED-style talk to play up the contrast and talk about its collaboration with Japanese sensor makers and farmers in the development of heat detection data analysis technologies. Dell Technologies exploits the contrast in a visualization of data leaving a cow's body in a video describing a partnership with Chitale Dairy in India. And of course, Lely's AMS is called the Astronaut, summoning visions not just of successful space missions, but animal astronauts and cosmonauts who perished in their service to human space aspirations.

The University of Waterloo's Critical Media Lab project Teat Tweets is made possible as an affordance of the data gathered by the assemblage of RFID collars, cows, milking robots, and social media. The CriMe Lab team developed a project to generate tweets from robotic milking data, in collaboration with the farmer and a dozen cows at Buttermine Farms in Ontario. The cows tweeted (via this enabling assemblage) from late 2009 into mid-2011. The Critical Media Lab team noted that AMS have "radically altered the daily rhythms of the dairy, as well as the farmer's relationship to the animals. The cows are now able to literally milk themselves at all times, day and night, and the farmer is now primarily an information manager" ("Teat tweet").

The lab developed a mobile app as an experimental intervention "that would allow the farmer to regain intimacy with his cows, and allow anyone at all to learn more about where their milk comes from," while noting as well that the project "[raises] questions about how technology mediates the relationship between animals and humans." According to the Lab's site, the farmer chose twelve cows of different ages and lactation stages to participate in the project. The Teat Tweet team prepared Twitter profiles for each cow, as well as a

> "voice" for each cow and ... a variety of tweet variables that would be used to flesh out data pulled from the VMS database. The result is a live and ongoing twitter feed for each of the 12 cows, which relay their milking activities in conversational terms, and sometimes quote lines of poetry from Virgil. ("Teat tweet")

The Crime Lab's Twitter script assembles the tweets like mad libs, by putting a wrapper around certain data points. So, the cows, ostensibly, tweet how much milk they produced, how fast each teat milked out, and frustrated visits to the robot. The accounts also tweet lines from Virgil's Georgic III. The cows' images appear on the Critical Media Lab website, and their twitter profiles are still active, though they haven't tweeted since 2011, and the cows, presumably, are dead.

The CriMe Lab twitter project inserts a mediating layer between cows and farmers, while it also creates a window to that relationship for curious bystanders. The project suggests a potential for new modes for bovine-human and bovine-computer interactions, while raising questions it does not answer. The project exploits the disjuncture between farming and computers, the idea of animals, let alone those with hooves, tweeting. Largely without context, it's hard to get a sense of the cows' experience in the robot, except by aggregating the tweets for analysis. Then we can count how many times each day a cow attempted to be milked. Charge Cindy, for example, had some days when she tried to enter the milking system 7 or 8 times, and 39 days when she only visited once. She visited on average 1.47 times per day in the 14 months she tweeted. Meanwhile, in the 16 months Attention Please tweeted, she visited an average of 6.56 times per day. Was Attention Please greedy for food bribes or was something else happening for her? She could not tell us.

Some eight years later, tweeting cows are no longer just the topic of a serious-playful exploration of the relationships between *Bos taurus* and *Homo sapiens* by digital animal studies scholars. Microsoft's Joseph Sirosh played up the contrast between cows and computers in a talk at the Strata+Hadoop World conference in 2015. In the talk "Connected cows?" Sirosh describes the pedometer-wearing cows whose step counts are "sent to the cloud." The step data are used to detect health problems and estrus using Microsoft's cloud data analysis platform. Sirosh's talk is playful and punning ("when AI [artificial intelligence] meets AI [artificial insemination]"), and plays up the idea that a farmer would receive texts based on this data, alerting "him" (in Sirosh's use) to the activity change that signals estrus (Sirosh).*

But perhaps most compelling are a series of videos published on YouTube in 2017 by Dell Technologies and subsidiary VMware. We are invited to "see how Dell Technologies is helping to transform dairy cows into living, breathing data centers and revolutionizing the dairy industry" through profiles of Chitale Dairy, a company in Pune, India, that uses the firm's cloud technology. In one striking 30 second video, actor Jeffrey Wright stands with a Brown Swiss dairy cow, lit in high contrast chiaroscuro.

She wears a collar with the number 2713 and an RFID tag and chews her cud audibly, as Wright gazes at her inquisitively. "A dairy cow that talks to farmers ... what kind of sorcery is that?" He answers his own question: "It's not the magic wand kind." As Wright touches the cow's forehead, her body appears to light up in multicolored laser tracery of her circulatory and nervous systems. As a grid of points appears on her body, Wright continues: "It's the RFID collar and Internet of Things kind we created with Chitale Dairy." Behind them, lighting begins to illuminate a background of green, rolling hills — perhaps the Swiss Alps that are the ancestral home of the breed. The cow begins to emit what appears to be an illustration of radio waves from her head as Wright explains, "so every cow can let farmers know how she feels, and what she needs to be healthier." At this moment, a reverse shot shows the point of view of both actors: they are on a stage in a large performance hall playing to an audience. Reversing again, the stage backdrop is now a view of Earth from space, and we can see the radio waves reaching a satellite in orbit. Wright's cell phone appears to buzz, signaling a received message, and he continues: "All with a simple text. Ta-da. Magic can't make digital transformation happen, but we can. That's the power of VMWare. Part of Dell Technologies" (Dell Technologies, "The Magic of Chitale Dairy").

The cutting-edge context set, other videos profile Chitale Dairy as if to contrast. In one, viewers meet Makarand Nagnath Patil, a farmer in rural Maharashtra, India, whose family and cows provide milk to Chitale Dairy (Dell Technologies, "How Chitale Dairy Takes Cows To The Cloud"). On the spare, simple farm, we see Patil and his family milk what appear to be a dozen or so cows by hand. With his young child, Patil transports milk in a large metal milk can by motorcycle to the Chitale collection center. Yet even this farmer, appearing to run a very small dairy operation with very few animals, can benefit from data produced by the cows on his farm in their milk, through cloud services provided by Dell Technologies and delivered via text. Patil, his cows and family, join others in the integrated circuit that is the global assembly line of bovine information work.

Back at the Pasture Dairy Center, I asked the farm manager about adapting the cows to the robot. I learned that it usually takes about three days for a cow to learn to operate the AMS, and that almost all of them are trained within three weeks. He cautioned that "cows will train you" to come get them from the pasture to be milked. The two robots at the farm handle 180 sessions each day, usually about two visits per cow, sometimes three. The recommended stocking rate is one robot per 50 to 60 cows, but at the Pasture Dairy Center farm they've learned that when cows are provided pasture, they come in less frequently and so more cows can be handled by the two robots. The most

surprising thing the staff of the farm have learned from looking at the milking data is one big way dairy farmers have been doing things wrong for generations: cows can come to milk any time they want, day or night, and the least popular time is exactly the time farmers have historically done the day's first milking, between 4:00 am and 6:00 am. The most popular hour, friendlier to both cows and humans, begins at 7:00 am.

The appearance of cows in these narratives is about the meanings and images cows carry: bucolic, placid, dumb, and the contrast with smart, cutting edge technology. They appear as rhetorical animals. Patil and his family are somewhere in between, a silicon pastoral: they milk cows by hand but benefit from knowledge derived from the data in the milk of their small herd. Nevertheless, Dell's vision of cows who are simultaneously living, breathing data centers and able to tell farmers how they feel via text message are "bodies as code problems on the grid of C3I [command, control, communications, intelligence]" (Haraway, "Cyborg Manifesto" 175). Sensor technologies and algorithms that detect indicators of health and other bodily states from their movements tell humans one set of stories about what cows feel and think. "Feminist cyborg stories," in the language of the Manifesto, "have the task of recoding communication and intelligence to subvert command and control" (175.) Haraway's "dream of a common language for women in the integrated circuit" (149) is ironic: "Cyborg politics is the struggle for language and the struggle against perfect communication..." (176).

Present in both Teat Tweets and in Dell's and Microsoft's claims to give cows a means to communicate with farmers is the paradoxical desire both to ventriloquize with cows to say something about what we think about them but also to actually understand something about what cows think and feel, and about what they want and don't want. Animal sciences, ethnology, stockmanship, animal husbandry, have each, in their way, tried to understand something about cows, even formed, as they are, through Foucauldian power-knowledge, such that cows can only be heard when they say something useful for human demands. As Coppin says, the animal sciences were born in industrial agriculture. Nevertheless, "agency is a temporally emergent phenomenon rather than a property inherent in some beings and not in others" (50) in the changing situations produced through human-bovine interactions.

Cowborg Politics/Program Robots, Not Cows. What are we to make of the predicament of bovines in the integrated circuit? It is not a predicament only of cattle, but of cattle, people, and other Earthly beings locked together in a struggle for survival. One effect of Haraway's and Grossman's references to electronics factory workers as women in the integrated circuit is to destabilize notions of high tech as "First World,"

masculine, clean, and untouched, by articulating a site for solidarity between more-than-women across categories structured by Western dualisms. Similarly, I trace the connectors of bovines in the circuit to destabilize the pastoral wholesomeness presumed to express cow living conditions. Cows are soldered into the integrated circuit, laboring in highly gendered, abjectly exploitative conditions of highly delimited agency that are occluded by our bucolic sentiments.

The technological apparatuses that seem to offer more freedom to cows are also nudges toward confinement systems that narrow the range of options available for bovine sensibilities. Coppin shows that "sows ... are active participants in hog farming and assist in the reshaping of several social agents." But nevertheless, "the primary relation between humans and swine is one of domination" (47). The imaginary of the Internet of Things is that not only documents and databases will be networked, but objects and even beings in the world, largely through the use of sensors that would track movements and other inputs to enable their manipulation at a distance.

Cows are not robots, nor are they "robot cows" as described in DeLaval's marketing materials. Formed, like humans, in technoscience, cows are cyborgs who operate dairy robots. Robots are electronically activated machines for automating repetitive tasks, from Czech *robota*, for forced labor. Cows through the 20th century have become, like humans, thoroughly constituted in the social relations of science and technology, co-laborers since the sledge and the plow, if not before, with bodies subject to the same breeding and biological discourses and practices. But cow robots could be built, designed to adapt to the variations in cow bodies and personalities that exist even under such intense selection pressures as are exerted through pedigree practices. Humans could program robots, not cows, to maximize bovine contentedness over the economic contradiction of high milk production. For this to be thinkable, humans with cyborg politics must account for our place with cows in the social relations of science and technology. As Holloway et al. argue, "robot technologies also demand a co-disciplining of the farmer and the co-constitution of particular human subjectivities" ("Recapturing Bovine Life" 137).

And yet. Robotic dairy work cannot be done without the cooperation of cattle, whether or not they understand that non-compliance is a death sentence. As with Coppin's pigs, the relationship between humans and bovines in the US-Canadian context is one primarily of domination. Still, AMS could enable humans to ask questions of cows that matter to them, and facilitate responses, including questions back, that we can hear. Cowborg politics takes stock of the social relations of science and technology to engage

scientific knowledge production for the task of imaginatively reprogramming robots and redesigning algorithms, intervening in cybernetic feedback loops that shape responses and responsibility of both bovines and humans.

In an interview with the *National Journal* that the National Pork Producers Council may never live down, spokesman Dave Warner said "I don't know who asked the sow if she wanted to turn around" (Terris). Of course, sows have been asked, and they've answered that they would prefer to turn and would prefer more space than the crates allow. They would also prefer not to die terrifying and painful deaths in slaughterhouses, though we will have to take that claim on our knowledge of porcine physiology and behavior, since swine informants don't survive the process to offer humans guidance on improvement.

How a human asks another human or another animal what it would prefer makes all the difference in the ability to perceive the response. A common way of asking cattle how they feel is to draw blood to test blood cortisol levels. Temple Grandin uses this research and keen observation skills honed through her experiences as a person with autism. Ian Duncan and colleagues who study animal behavior with attention and curiosity design experimental set ups that allow fish, chickens, pigs, horses, and other farm animals a chance to understand a choice and meaningfully answer (Fraser et al.). These questions are shaped through contemporary animal sciences. Thelma Rowell's work was "to expand the repertoire of hypotheses and questions proposed to the sheep" (Despret, "Sheep Do Have Opinions" 368).

Cows do have opinions. Good cattle handlers and ox drovers know how their bodies inflect to cows. Any farm kid knows how far to go around a cow and where to enter her flight zone to encourage her to turn. Too close and she'll turn hard, too sudden a move and she'll bolt. Staying quiet and calm keeps cows quiet and calm. Cows listen to people and people can listen to cows. Cyborg politics demand new research questions.

Animal welfare knowledge provides some of the argot for creating channels for communication with bovines. But it may assume too much welfare provided by humans and be unable to detect other states of wellbeing or un-wellbeing. Cowborg politics acknowledges crucial differences between kinds of beings but also similarities in human and bovine sensory systems, shared histories, and co-domestication. It incorporates impure knowledge from animal sciences, ethology, pastoralists, and agriculture to generate a permanently partial language that takes cow pleasures and perceptions seriously. It inhabits historically constituted relations with farming animals

while rejecting the capitalist logic of utter domination and resourcing of animal bodies, against which animal welfare is a failing bulwark.

Computational technologies, working with larger sample data from a seemingly endless stream of animals due to ARTs and industrialization, predict economically beneficial traits that can be correlated to genetic markers. Auxiliary technologies like AMS are purported to enhance cow agency, requiring less knowledge of cattle behavior and preferences from the humans they encounter. Rather than eliciting response and responsibility (Haraway, *When Species Meet* 71) from humans who live with cows, the techne of the algorithm entices humans to attempt to create cattle as docile beings whose temperaments are suited for unskilled handlers and whose bodies are fitted to robots. Changing the machinery of dairying requires a change in the biology of cows, bred for docility and compliance, as a component of the dairy assemblage, creating a nightmare for cattle. High-yielding dairy cows require constant access to nutritionally dense feed in order to meet the calorie requirements of milk production and get their work done within each day's time budget, even while the contradictions of capital sometimes require the dumping of milk to support prices given cows' increased productivity. If cattle become compliant with permanent warehousing, this could mean a major change in animal agriculture, and the amount of open space required for dairying. The need to resist this is acute.

Yet, robots could be programmed to allow cows a way to be interesting, to tell us more than the time of day at which they prefer to milk, which would be good for cows and human-bovine companionship. I position this against some extreme forms of animal rights discourses that would see not just the end of cattle breeds of any kind but domestic cattle altogether. Animal rights discourses that insist that all human-non-human animal relationships are exploitative reinscribe the line so thoroughly breeched by cyborgs between animals and non-animal humans, nature and culture, and the rest of the Western dualisms scuttled by Haraway, Anzaldúa, and others. While, like the pigs in Coppin's swine study, the relationship between cattle and humans in industrial settings is primarily one of domination, in the lives of very large numbers of subsistence farmers all over the world, the fates of cows, yaks, buffalo, and other *Bos* kin and their human companions are more directly intertwined. Traditional lifeways that have been only barely possible would be absolutely impossible were relationships between people and Bovids forbidden. Yet capital appears ineluctably to find its way into parts of the world that had previously been remote to it, imposing visions of cow bodies as data centers, and introducing new mediations in those relationships. In acknowledgement of the long-shared histories between cattle and people for which I carry a gene for lactase

persistence as testimony (Beja-Pereira et al.), I am holding out for a cowborg politics that acknowledges this companionship, the cyborg status of all of us living through the Informatics of Domination/Domination of Informatics, and the shared stakes in Earthly survival for all cyborgs.

Human workers who have dreamed, not feared, robots taking their jobs, or at least reducing the hours of the work day, can understand the contradictory dream of dairy robot stocking ratios and pedigree practices that hold productivity static or dial it down a notch, but produce more hours in the day for, as the slogan of the Eight-Hour Movement goes, "what we will." I can barely imagine human lives made less abject but I insist on continuing to do so, with bovines as our co-laborers and collaborators (in every radical sense) all the way. We will not be made ready for the robot. We are ready, and will make the robot ready, for us. With love and deference to Susan Leigh Star (46) and Donna Haraway, I note: a cow is already a goddess and a cyborg.

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Note

*Although heat detection data sent through SMS has been around for several years, no one yet appears to have adopted the slogan "twat tweets" or "twatter."

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