DECODING COWS

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FOLLOWING COW PATTERNS

This book is about cows — past, present and future. Often positioned as both symbols and scapegoats in environmental debates, cows inhabit our societies as biological and cultural figures, entangled in histories, economies and imaginaries. If you ask around, someone is likely to have a cow story. Paying attention to the subtle and not-so-subtle traces of bovines in everyday life, our research seeks to follow the small narratives that lie in the vast infrastructures of agro-industry and biotechnology.

To where and to whom do cows belong?

Distant from the pastoral landscapes they are often associated with, bovine lives play out in the liminal spaces of science, capital, and culture. This inquiry into cows' existence actually started through another research project conducted in the medical genomics unit at Liège University Hospital. Cows appeared everywhere: in wallpaper decorations, in the schedules of scientists who split their time between the biomedical research centre and the Walloon livestock agency, and as financial assets of the biomedical research centre itself. They were present in the scientific instruments and, in turn, shaped methods and knowledge in human medicine. These overlaps brought into question the fragility of the human-animal boundary, and cows emerged as a recurring, even obsessive, pattern.

Genomic technologies promise not only to heal humans but to shape the ideal animals of the future. Thus far, social sciences have mostly taken an interest in the medical domain through the Human Genome Project and its big promise of improving disease prediction and healing. Yet, livestock genomics is witnessing fast-paced developments with the promise to improve breeding programs by targeted selection, from maximizing meat and milk yield to understanding antimicrobial resistance in livestock as a global threat for both human and animal health. Philanthropic and corporate actors such as the Bill and Melinda Gates Foundation have invested heavily in livestock genomics. One such venture recently pledged over £40 million to an Edinburgh-based lab to design "the perfect cow"[1]. These developments are not isolated. An everyday genomics infrastructure has emerged, routinely used in late capitalist societies for the selection and reproduction of bovines. In other words, cows have been progressively incorporated within industrial systems through standardization processes, where animal lives are shaped at the confluence of biology, zootechnics and bioinformatics.

Yet, this logic is meeting its limits. The intensification of livestock farming, particularly in the dairy cattle industry (sometimes referred to as its 'Holsteinisation'[2]), is increasingly unsustainable. While the global demand for animal products is expected to double by 2050, intensive farming is threatening biodiversity and exacerbating environmental crises. According to the Food and Agriculture Organization (FAO), the world's livestock produces 12 percent of all anthropogenic emissions[3]. Among the different species, cattle are the primary source, accounting for approximately 62 percent. Climate change brings current practices into question and challenges the ideal of the 'global cow' — a cow that is standardized, deterritorialized, highly productive, and evaluated through international indexes. Therefore, since the early 2010s, actors in the genomic infrastructure are shifting their focus from maximizing yield to enhancing resilience, increasingly targeting inherent genetic capabilities of diverse breeds that may be more adaptable to new climatic conditions.

For over a decade now, many scientists have studied and voiced concerns about the impact of climate change and heat stress on ruminants, aiming to identify genetic markers of climate adaptation[4]. Such work suggests that future herds could be genetically selected to endure extreme weather. With genomics, cows' bodies are increasingly being invested in as sites of social concern to remedy both the pitfalls of the livestock industry and wider environmental disorders. In doing so, genomic infrastructure offers to solve pressing social issues such as improving the health of animals, lowering their environmental impact and enhancing biodiversity. Cow bodies are becoming sites not only to meet market demands, but also to mitigate ecological collapse.

These developments also raise questions about the values that are encoded in livestock bodies. How are bovine bodies transformed by these values, and through what techniques, practices, and infrastructures? From the lab to the barn, where are the cows?

A few years of inquiry later, this book is a reflection on the entanglements of bovines, biotechnologies, and the social worlds they inhabit. We trace cow patterns across sites of genomic research, fieldwork encounters, the evolution of bioinformatics, philosophy of science, zootechnical history, and selection and reproduction techniques.

The book begins with an exploration of how value is inscribed in bovine life. Jenske Bal opens the volume by devising ten ways of being a "good cow". What makes a cow good or bad reveals biopolitics that run deep and govern cow lives and deaths. Pauline Chasseray-Peraldi then turns to bioinformatic infrastructures, analyzing how biological data are produced and circulated through genomic technologies. Zooming into the small scales of genomics, Simon Vanderstraeten reconnects the concept of the 'gene' to its generative roots by looking at how Belgian-Blue cattle embodies it. A selection of photographs taken by Téo Becher, drawn from Roxane Gabet Severne's fieldwork, offers a visual interlude on the poetry found in the details of barns and human-bovine companionship. We then encounter the story of Aurore B., as told by Roxane Gabet Severne, who traces the haunting presence of "the cow of the future" from the lab to the farm.

Daniele Valisena unveils another kind of ghostly figure by opening the archive of animal husbandry practices in a newly unified Italian Kingdom, and later in the Fascist imperial regime. Exploring another dimension of taxonomy and classification systems, François Thoreau unfolds the poetics and politics of an animal protection regulation issued by the Swiss Federal Food Safety and Veterinary Office. To close our loop, Roxane Gabet Severne and Shana Riethof offer speculative writing experiments which brings together genetic testing for human reproduction and genome editing in cattle breeding to reflect on what justice in cross-species relationships might look like.

Bovine lives are profoundly industrial and technical. They are shaped by genomic science, climate change pressures, and capitalist imperatives. Yet cows' stories also reveal entangled worlds, deep power dynamics, multiple relational attachments, and thought-provoking multispecies assemblages. Through this volume, we intend to draw such connections to enrich the perception of bovine worlds while sharing new codes to interpret potential futures where cows belong amongst us.

Pauline Chasseray-Peraldi

1 Lou del Bello, "Bill Gates Is Working With Geneticists to Create the 'Perfect' Cow," *Futurism*, January 29, 2018, https://futurism.com/bill-gates-working-geneticists-create-perfect-cow.

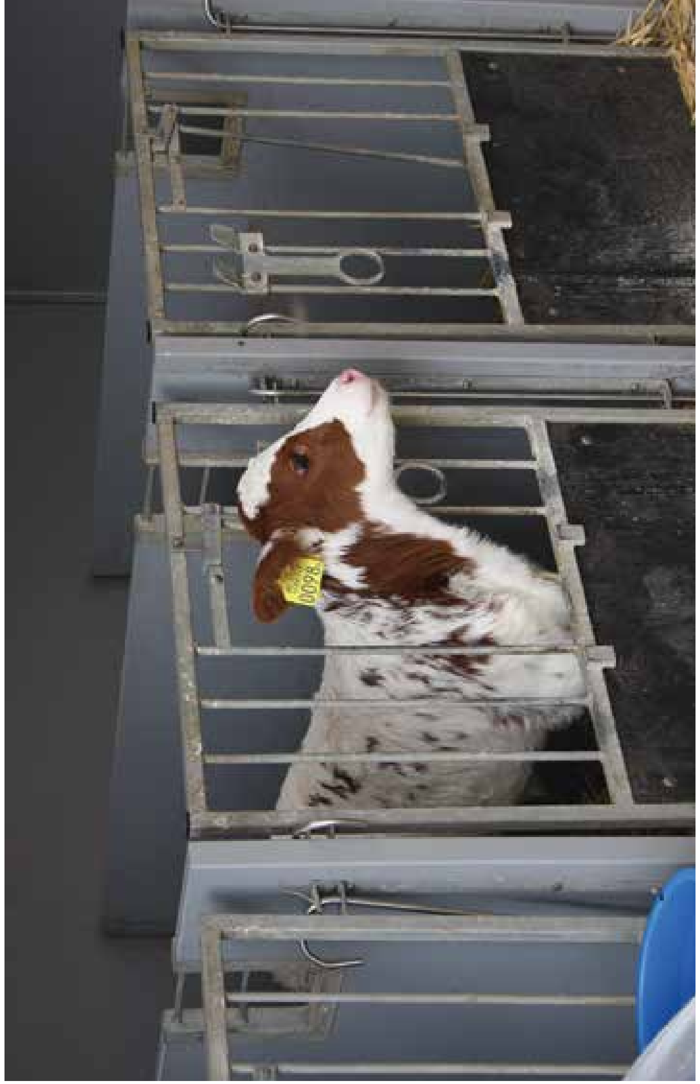
2 Bert Theunissen, "De Friese-Hollandse zwartbont in de twintigste eeuw: Van melkspecialiste naar dubbeldoelkoe en weer terug," *Tijdschrift Voor Geschiedenis* 125, no. 4 (2012): 536–551; Julie Labatut and Germain Tesnière, "The Holstein Cow as an Institution of the Agricultural Modernisation Project: Commodity or Common Good?," in *Ecology, Capitalism and the New Agricultural Economy* (New York: Routledge, 2018), 163–180.

3 FAO, *Pathways towards lower emissions – A global assessment of the greenhouse gas emissions and mitigation options from livestock agrifood systems.* (Rome: FAO, 2023).

4 Matilde Maria Passamonti, et al., "The Quest for Genes Involved in Adaptation to Climate Change in Ruminant Livestock", *Animals 11*, no. 10 (2021): 2833, https://doi.org/10.3390/ani11102833.

10 WAYS COWS ARE GOOD

JENSKE BAL



Floatting Farm, April 2023, picture taken by author.

When engaging with farmers about the breeding and selection practices, I often found myself speaking to them about what makes a cow *good*. In this piece, I discuss how cows are enacted as good. The key point I want to make here is that these *valuations* shape the lives and bodies of the cows involved. *Good* cows are more likely to become mothers of newborns, while *bad* cows are more likely to be sent away to the slaughterhouse. As Annika Lonkila and Minna Kaljonen put it, “livestock breeding is an exercise in value creation: certain individuals are deemed valuable while others are rendered killable”[1].

In their paper on good tomatoes, Frank Heuts and Annemarie Mol[2] teach us that valuing involves both *knowing* what is good and *making* something good. Valuing is both evaluating and valorising. Breeding as a practice of reproduction and selection is a textbook example of valuing. Farmers classify cows as either good enough to keep or not, and they also improve their herd by selecting and breeding. Valuations are also shaped by the way cows are classified into breeds. Catherine Nash argues that “the nature of their lives and deaths is determined by the function of the breed, and by their differentiated value within the breed and potential to reproduce or enhance the breed through their offspring”[3].

Based on my fieldwork (2021-2024) with breeders, farmers, conservationists and breed organisations, I have identified ten ways in which *good cows* emerged. My informants are concerned about a handful of cow breeds that are considered ‘native’ to the Netherlands: the *Fries-Hollandse*, the *Blaarkop*, the *Maas-Rijn-IJssel*, the *Brandrode*, and the *Lakenvelder*. They are worried about the future of these breeds and fear they may become extinct.

This context is important because others may have other ways to stage cows as good. Most of my informants would, for example, define their farm as ‘extensive’ as opposed to ‘intensive’. They continuously emphasise that their cows graze outside, that they avoid ‘inputs’ such as artificial fertilisation and concentrated feed, and that they sow different grasses and clovers, and plant trees and bushes. They state their cows are not very productive in terms of milk, which remains the main source of income for most Dutch cattle farmers. However, this creates opportunities for other ‘goods’ such as biodiversity and sustainability.

For my informants, highly productive breeds, such as the Holstein, have become a symbol of intensive industrial farming practices, which are causing ecological trouble. This brings me to my first of ten points:

1 GOOD COWS ARE NOT HOLSTEIN

Around ten years ago, farmer Luuk transitioned from 'conventional' to 'organic' farming. His cows now graze outside as much as possible, feeding on the available pastures. During the transition, he farmed with Holsteins but soon noticed that "they found it difficult here, especially to keep the same body condition". The Holstein needed more feed, but this was no longer available. Luuk therefore started looking for a breed that would perform better in his 'system' and ended up with the *Fries-Hollands* [Friesian Dutch], one of the Dutch heritage breeds.

Another farmer, Ben, shares this sentiment: "I think that within the system that we have, there is no place for highly productive breeds like the Holstein. If they only get grass, they won't last". He explains that his *Brandrode* [Dark Red] breed fits well on his farm, where the cows graze as much as possible. When asked what makes this breed so well-suited to his farm, Ben replies that these are cows "that actually do what cows are meant to do", living off 'roughage' [non-processed feed]. In contrast, Holstein cows require too much feed and are too high-maintenance. According to Ben, this is not sustainable agriculture: "I think that our breeds [Dutch breeds] will have a future in changing agriculture".

According to Ben, the Brandrode cows should not only have the right metabolic qualities, but they should also be eligible for the studbook. This brings me to my next point:

GOOD COWS ARE PUREBRED 2

Purebred cows are those whose ancestors are all from the same breed. Purebreds also fit the 'right' breed descriptions and are safeguarded by breed associations. Ben explains what his Brandrode cows should look like: "The markings are important. She must be dark red all over her body, with white socks, a white tail and a white belly, but not too many white spots elsewhere". Ben served on the board of the Brandrode breed association and believes it is important to sustain the breed in its pure form.

Another farmer, Diederik, has cows from the *Lakenvelder* breed. These cows are black or red and have a white sheet around their waist. While standing in his barn, Diederik points to one cow that did not have a proper sheet around her waist, but more of a thin stripe, "but it is a super cow, one of our easiest". In this case, for Diederik, being easy-going overrides the need for a perfect, purebred appearance. Easy means that she does not cause too much trouble, that she is calm, or in other words:

3 GOOD COWS BEHAVE WELL

Diederik points to a cow fidgeting around her stable. He starts telling me about this cow's mother: "We used to have a cow, she was one of our firsts, and she was such a real boss. This is her daughter, and she is the same. At one point we were so fed up with her that we just got rid of her". Directing his attention to the cow in the barn, he continues, "That might happen to you too, huh, sweetie". When a cow is too bossy, according to Diederik, she can take up all the space and frighten the other cows. This causes too much trouble.

When I asked Diederik what else he looks for in a cow, he told me that it is essential for him that cows are pregnant on time because he wants all the calves to be born in spring. This ensures that the cows and calves are well-fed when the freshest grass is available. Cows gestate for nine months, so Diederik inseminates all these cows at the same time in the summer. So:

GOOD COWS GET PREGNANT IN TIME 4

Diederik explains: "I don't want to keep empty cows over the winter. In principle, it's just like, not pregnant, tough luck, off to the butcher". However, Diederik does add some nuance: "Sometimes there are cows that I don't want to get rid of. Then you have a dilemma". He explains that he then tries to get them pregnant later, meaning they will produce offspring later, but at least they can stay. The cows that he does not want to get rid of usually produce enough milk and are healthy, and do not need so much care; in short, they cause no trouble.

5 GOOD COWS ARE TROUBLE-FREE

I am attending a farmers' study for one of the Dutch cattle breeds, the *Groninger Blaarkop*. The event is taking place at Roos' farm. She tells us that she chose the Blaarkop because she likes them, and that by choosing a breed different to Holstein, she can stand out from the other farms in the area. She likes to do things differently. As I walk around in the long barn where cows of different ages are standing or lying down, I start talking to Jelle and Vincent, who are both dairy farmers with Groninger Blaarkop cows. I ask them which cow they like best and why. Vincent points to a cow named Gemma 49, and when I ask him why he likes her, he seems hesitant to answer and eventually says, “A good cow for me is a cow that does not stand out”. Jelle responds jokingly: “One whose name you have already forgotten”. I think they mean that a good cow causes the farmer no trouble. A good cow is trouble-free.

As I continue walking through the barn, I talk to Judith, a board member of the Blaarkop association, and ask which cow she likes. She points to a cow with good posture.

GOOD COWS HAVE GOOD POSTURE 6

Judith likes to look at cows that are ‘in balance’, with a cohesive posture. She points to another cow and says, “That one is clearly crossbred with a Holstein. You can see that the middle section is a different height and structure from the front and the back. I don’t like that”. Judith associates a good, balanced posture with the Blaarkop as opposed to the Holstein. To her, Holsteins have a body structure that is not aesthetically pleasing.

I also talked to Jelle about the cow’s posture. When I asked him what he first looks at when observing the cows in the barn, he told me, “First, I look at the feet. They need to be firm and not too close together”. He points to one of the cows in the stable, “Look. You do not want that. This cow is not standing stable, which can cause trouble later, when, for example, she cannot walk to her food properly. Then it’s more difficult for her to grow old”. What I think Jelle means is that, if a cow has too many issues, she is likely to be sent away before ‘growing old’. This is to be avoided, as:

GOOD COWS LIVE LONG 7

In an interview on his farm, farmer Tim tells me that the main breeding goal for him is the lifespan of his cows. When he buys semen to inseminate his cows, he considers the retention rate — how long a cow stays on a farm — as an indicator of how long its ancestors stayed around. For his cows to live as long as possible, they need not only to have good genes but also to stay healthy. One issue he has had to deal with is that a few of his cows have developed eye cancer. These were all white-skinned cows, and Tim believes that this made them more susceptible to sun exposure. Consequently, he began searching for cows with more pronounced pigmentation around the eyes. He also started thinking about heat resistance and heard that red skin would be better at withstanding heat.

Gemma 49. Picture taken by author.

8 GOOD COWS ARE RED

Now Tim only works with red cows from many different breeds. In his words, he has “let go of the concept of breed”. He selects bulls for artificial insemination from various breeds with red skin, including those from neighbouring countries. Tim explains that all breeds can possess the qualities he is looking for and that he does not believe the Dutch breeds should be representative of specific qualities. “People say the Fries-Hollands or the MRIJ are so quiet, but in the end, these all come from the same breed when you go back long enough. And I also have a few bastards from the MRIJ breed, these are not automatically quieter”.

Another farmer, Daan, has MRIJ cows — purebreds. This breed is named after three rivers that flow in the Netherlands: the Maas, the Rhine, and the IJssel. MRIJ cows usually have a white coat with red spots. Daan also wants to maintain these red spots: 'There are MRIJ cows with much higher production, but they turn whiter and whiter. Well, I think that's boring.' Good cows have a bit of red.

Daan chose this breed because, in his words, “they take good care of themselves”, which brings me to another way a cow can be good:

GOOD COWS ARE SELF-RELIANT 9

Daan’s cows can take good care of themselves. This means that when he lets them graze on the land, they can feed themselves well. “They eat what they need,” he says. The quality of the land varies from time to time, and Daan puts a lot of work into maintaining the vegetation, but poor-quality grass should not be an issue for the cows as “they are nice and fat and can handle changes to their diet”. Daan’s cows are thus self-reliant in that they can fend for themselves, and their metabolism is not too fragile.

Daan chose the MRIJ breed for his farm because he believes it is nice to continue a tradition, and so it is important that:

GOOD COWS ARE DUTCH 10

Daan attended an afternoon discussion with other farmers who keep Dutch cattle breeds, which I helped organise. Another farmer asked Daan why he had chosen the MRIJ breed, to which he replied: “The MRIJ fits my vision. My grandfather had MRIJ cows, my father had Holsteins, and then I started with MRIJ cows again. There's an element of nostalgia, too. I have a feeling that the MRIJ belongs here and that it has the genes to do well. It’s a romantic image”. What I find interesting is that Daan sees the MRIJ breed fitting into the Netherlands both culturally and naturally. The breed should be here because of tradition, but also because the cows' genes have adapted well. He adds, “If I were a farmer in Austria now, for example, I would also take a breed from there”. Good cows are Dutch, at least in the Netherlands. For Daan, good cows belong.

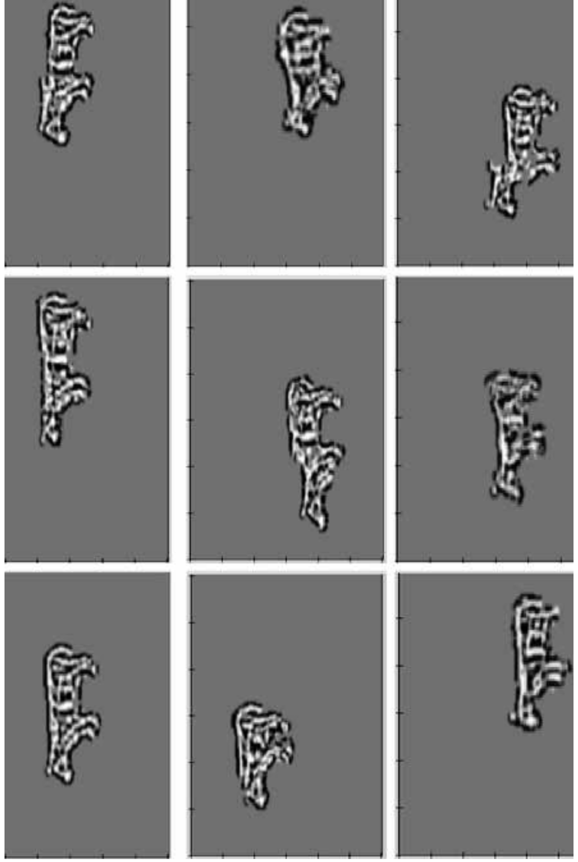
1 Annika Lonkila and Minna Kaljonen, "Animal Bodies Multiple: Practising Genomic Knowledge on Dairy Farms," *Geoforum* 96 (2018): 198.

2 Frank Heuts and Annemarie Mol, "What Is a Good Tomato? A Case of Valuing in Practice," *Valuation Studies* 1, no. 2 (2013): 125–146.

3 Catherine Nash, "Valuing Difference: How Breed Matters for Animal Lives and Relations," *Environment and Planning E: Nature and Space 7*, no. 2 (2024): 703.

FROM COW TO CODE: HOW GENOMIC DATA ARE MADE

PAULINE CHASSERAY-PERALDI



“Beyond Captcha, Vicarious's visualization software still needs work. In the example of the cows, the images are pixelated and in grayscale. While the software successfully created cows in varying positions—by pulling not only from its knowledge of a cow's image but also how other animals it has seen behave, move and distribute body weight—some cows still came out distorted. One it drew, for example, had a very long neck.” Everlyn M. Rusly, “Attempting to Code the Human Brain. Startups, Tech Giants Expand World of Artificial Intelligence; Software With an 'Imagination'”, *wsj.com*, Feb 3, 2014.

> “Somewhere, in a glass building several miles outside of San Francisco, a computer is imagining what a cow looks like. Its software is visualizing cows of varying sizes and poses, then drawing crude digital renderings, not from a collection of photographs, but rather from the software's ‘imagination’.”[1]

Looking at the representation of a cow by the Vicarious Artificial Intelligence (AI) software from 2014[2], each example shows a variation of the idea of a bovine, projecting behaviour, postures, and morphologies into an ever-evolving cowish pattern. By weaving together bits of code inspired by the human brain, this start-up aimed to create a machine that can think like a human, with the aim of generating less pixelated patterns.

> “‘We don't have the perception problem solved,’ said Mr. Phoenix, the founder of Vicarious, in 2014. ‘Vicarious said it may need another five to ten years and more engineers. But if it can graduate beyond pixelated cows, the payoff could be huge.’ ”[3]

Back in 2014, this AI software was holding huge promises for the development of AI, especially in robotics intelligence, and objects classification. Alongside the likes of DeepMind, Vicarious is one of these secretive start-ups supported by the Founders Fund run by Peter Thiel, that are of great interest to Facebook and Google. After only a few years, in 2021, the start-up became the ownership of Alphabet (Google's holding) under the name of Intrinsics and specialized in industrial intelligent robotics.

Somewhere, in a glass building several miles outside of San Diego, a different company called Illumina Inc. has been transforming cattle into data since 2007. It turns each cow from a unique living being into a set of small data points that can be compared, optimized, predicted to then be controlled, bought and sold.

> “It can be difficult to explain genotyping to consumers. It's important for us to communicate the way we are working and that genomics is a tool for us to use that doesn't modify anything. It's more like genotyping provides us with a magnifying glass so that we can get a better look at the animals.”[4]

Illumina Inc. is an American biotechnology company, headquartered in San Diego, California, specialised in genomic sequencing and analysis technologies for precision medicine, genetic research and agricultural genomics. By collecting DNA samples, producing specialised microchips, and sequencing machines to read the cow's genetic code, Illumina Inc. has progressively contributed to the creation of a global data infrastructure for bovine genetics that influences breeding decisions worldwide. The metaphor of the "magnifying glass", which is used in their presentations about genomics as an optical instrument, evokes visual imaginaries of scaling-up and down to enhance what we might be able to see and know. Though, considering the centrality of Illumina's product on the market nowadays, the purpose of their work, and the place of cows within it can be put under its own microscope.

This chapter thus departs from two main questions: how are cows turned into data which is available for genomic science? What technology mediates bodies into data, for which purpose, and whose benefit?

It is precisely at the scale of a microchip that Illumina majorly contributed to the process of turning bovine bodies into interpretable information. This is how they became a key actor responsible for shaping the present and future of breeding practices and computational biological knowledge.

As described by Jennifer Gabrys, Chair in Media, Culture and Environment, "a miniature device that performs seemingly immaterial operations, the chip, in fact, requires a wealth of material inputs"[5]. According to her, a microchip can be understood as a site where materials, environment, bodies, politics, technologies, ecologies, and economies accumulate:

> The microchip appears to be a thing in itself, similar to the way in which Haraway describes the gene. This is the way in which commodities are fetishized; they seem to be free-floating and without consequence. Yet the microchip, like the gene, requires "all the natural-social articulations and agentic relationships," from "researchers" to "machines" and "financial instruments," in order to circulate in the world.[6]

Following this insight, this text traces the genealogy of Illumina Inc. through a specialized chip called the BovineSNP50 BeadChip. This is a genotyping microarray designed specifically for cattle genetics. With this focus, I aim to emphasize the materiality of computational biology and how it mediates bovine bodies, for a better understanding of the specificity of bioinformatics perception, and to delineate a natural history of genomic chips.

"Livestock Decoded", *Science*, Volume 324, Issue 5926, 24 April, 2009.

FROM FLESH TO DATA: THE RISE OF ANIMAL GENOMICS

Genomics is often described as "the datafied version of genetics". Genetics refers to the study of genes and their roles in inheritance, in other words, the way that certain traits or conditions are passed down from one generation to another. Genomics is the study of all of an organism's genes (the genome), including interactions of those genes with each other and with the organism's environment. Generally, genomics is recognised to have arisen only in the 1980s with the Human Genome Project which completed sequencing the human genome in 2003. Progressively, genomic technologies were extended to non-human species, with the intent to get precise information on the genetic potential of an animal at an early age, to help breeders to make better breeding decisions.

Some scholars trace the birth of animal genomics back to exactly 1983 and the research of Morris Soller and Jacqui Beckmann[7], two geneticists who were both committed to mapping agriculturally important biological traits (any observable feature or character of an organism, whether acquired or inherited) at a genome-wide level[8]. Indeed, Morris Soller strongly believed in the possibility of genetically mapped economically important traits in livestock, and optimising their performance for specific, and sometimes ideological purposes[9]. These early mapping efforts laid the groundwork for a major breakthrough.

On April 24, 2009, the field of animal genetics reached a major milestone: the bovine genome was officially sequenced in full. This event was reported in the journal *Science, featuring also on the issue*'s cover as a close-up picture of a cow, in whose eyes floats a double helix strand of DNA.

Using the magnifying glass of biotechnology, we can see into her body and read the precious genetic code that constitutes her. This breakthrough resulted from a collaboration between the Bovine Genome Sequencing and Analysis Consortium and the Bovine HapMap Consortium, with more than 300 scientists from 25 different countries looking for what Harris Lewin, director of the Institute for Genomic Biology at the University of Illinois at Urbana-Champaign called the "essence of bovinity"[10], or "what makes a cow a cow" from the genes devoted to reproduction, lactation and immunity.

It took $53 million and 6 years for this genomic research until it was able to make national and international headlines: “the cattle genome reveals its secret”[12]. But the study goes beyond understanding cows themselves. “Livestock decoded” reads the *Science’s* cover. Beyond understanding biological organisms, the research programme aims to improve livestock productivity for the agro-industrial market. They performed this mapping on livestock in two main steps. First, they identified quantitative trait loci (QTL) which are specific genomic locations on a DNA strand that influence quantitative traits such as height, milk or meat productivity. Second, they enhanced these desirable alleles (good versions of genes in regard to a certain goal) in breeding populations, selecting desirable individuals in a breeding scheme based on DNA molecular marker patterns[13].

But to decode the genome, a biological organism is needed at first to serve as a standard for the species. The choice of this standard cow embeds specific industrial values into the very foundation of bovine genomics. The cow genome was decoded after L1 Dominette 01449 was sequenced. L1 Dominette 01449 was a 8 years old, 1,300 pound white and brown Hereford cow who used to graze on a ranch in eastern Montana.

L1 Dominette 01449 was “the chosen one”[14]. Born on the 14th of April in 2001, she was a product of the Line 1 (L1) Hereford cattle breeding program at the Livestock and Range Research Station in Miles City, Montana (U.S.A.). L1 Herefords were first developed and bred in 1934 by the U.S. Department of Agriculture (USDA) animal scientists as part of a strategic effort to improve beef cattle production systems. They have become a reference in the beef industry due to their high-quality meat and adaptability.

L1 Dominette 01449.

One of the aims of genomic selection is to increase the gain of economically significant traits. The passage from genetics to genomics can be understood as a switch of scale from the small and detailed to the *wide and multiple*. Genomics offered a qualitative change in the understanding of the genome as something working as a complex network rather than a set of individual genes. From this perspective, genomics can be seen as a mediator between data and bodies, as the datafied version of genetics. This is done by reducing the time between each generation of new cows to enhance the intensity of the selection of the male parents called sires for artificial insemination.

The deployment of such technologies came with utopian promises of being able to shape the ideal animal of the future. An ideal that motivates the ones developing these biotechnologies, as we can read in Morris Soller’s paper wrote in 2015:

> There is one more horizon we can see—precision genetics and precision husbandry—to design and construct genetic and husbandry systems for optimal performance, with maximum sustainability and minimal environmental footprint, so that our cow of the future produces well, reproduces readily, and lives a long, happy, and healthy life, while maintaining environmental neutrality.[16]

Depending on breeding objectives, various traits can be sought, improved, mitigated or promoted, making it possible to design diverse farm animals adapted to social, ecological or economic challenges. Choosing L1 Dominette as a reference also meant choosing a set of standards that would fit well within the cattle and agri-food industry.

THE BOVINESNP50 BEADCHIP: GENETIC VARIATION MADE VISIBLE

Bovine selection and reproduction in the genomic era normalise the idea of turning a cow into data. This tendency must be questioned, as data are not restricted to genomics. Data are produced through various machine perceptions which treat and interpret them through layers of hardware and software. In fact, data, in all their seemingly immateriality, require a heavy social and material infrastructure. Data are not an index of something in themselves, they belong to a context in which they are produced and interpreted both by machine perceptions and humans.

Sequencing the bovine genome was also permitted by new methods such as single nucleotide polymorphism (SNP) genotyping, which became more affordable and therefore better fit for industrial uses. SNPs are a kind of genetic marker which represent the smallest change in the genetic code. As SNPs are abundant and evenly spread throughout the genome, they offer a way to target functional regions in a genome through high-resolution genetic studies and large-scale research. The goal of this method is to allow the generation of large numbers of genotypes in a relatively short period of time and for minimal cost[17]. These methods rely on technologies called SNP array designed for these purposes.

After years of development in optimizing SNP array technology for bovine genomics[18], the BovineSNP50 chip was created. The BovineSNP50 BeadChip can be understood as a new form of agricultural infrastructure that has the potential to transform any individual cow into a comparable dataset. Its proliferation has created a global genetic market where breeding decisions are increasingly driven by algorithmic predictions.

This beadchip was developed by Illumina in collaboration with the United States Department of Agriculture (USDA), Agricultural Research Service (ARS), the University of Missouri, and the University of Alberta for the interrogation of genetic variation in cattle. On August 24, 2006, Illumina Inc. announced that they had signed a commercial agreement to develop a new multi-sample Bovine BeadChip. The BeadChip is particularly well suited for genome-wide enabled selection, identification of quantitative trait loci (QTL), evaluation of genetic merit of individuals, and comparative genetic studies.

This high-density chip contains 54,609 informative SNPs evenly distributed across the entire bovine genome, allowing for precise genetic analysis. The Bead-based microarray technology is based on 3-micron silica microbeads that self-assemble in microwells on planar silica slides creating what Illumina called “BeadArrays”. These beads are coated with multiple copies of an oligonucleotide probe targeting a specific locus —a SNP— in the genome. When a DNA sample is applied to the chip, matching sequences bind to their corresponding beads and emit fluorescent signals which convey information about the allelic ratio at that locus. These signals can be read and quantified by automated scanners equipped with specialized software.

Preparing a genome-size microarray is generally too big a demand to be fulfilled by individual scientists and research labs. Typically, they will be purchased from biotechnology companies such as Illumina or Thermo Fischer Scientific who are equipped to manufacture them in large quantities.

Biological materials require translation into data to be made statistically readable. This is the function of the microarray alongside a whole set of equipment: sample tubes, pipettes, a scalpel, columns with oligo-dT Beads, solvent and buffer solutions, a microcentrifuge, a vortex, green and red labeling mixes, pipettes, a microarray washing solution, a microarray scanner and a workstation.

The physical transformation of biological information into digital data relies on four basic steps. Firstly, the preparation of the DNA sample extracted from a cow (through blood, a piece of hair, or soft tissues and cartilage). Secondly, creating the cluster generation that is a process to amplify DNA samples[19], by placing them on a specialized microchip called a “BeadChip”. Thirdly, the use of advanced microarray scanner technology[20] to “read” the cow’s genetic code. And lastly, the conversion of biological information into digital data for statistical analysis.

Bovine HD microchip and iScan system
©2026 illumina, Inc.

Once processed, a large final report file is generated with SNP data and the connections with the animal’s information. The data are now available for analysis and statistics. Some of the probes featured on the BeadChip, target SNP which were discovered by sequencing three pooled populations of economically important beef and dairy cattle. The SNPs selected are based on various sources such as the BovineHapMap Data set, publicly available resources like the bovine reference genome, and additional sources as the Holstein Bacterial artificial chromosomes (BAC) sequence data[21]. All 54,609 SNP probes on the BovineSNP50 BeadChip have been validated in nineteen common beef and dairy breeds, from Holstein to Charolais, themselves all defined by breeding standards. What is called “Genomic prediction” is the calculation of the animal’s estimated breeding values based on sequenced data for various traits which inform breeding decisions.

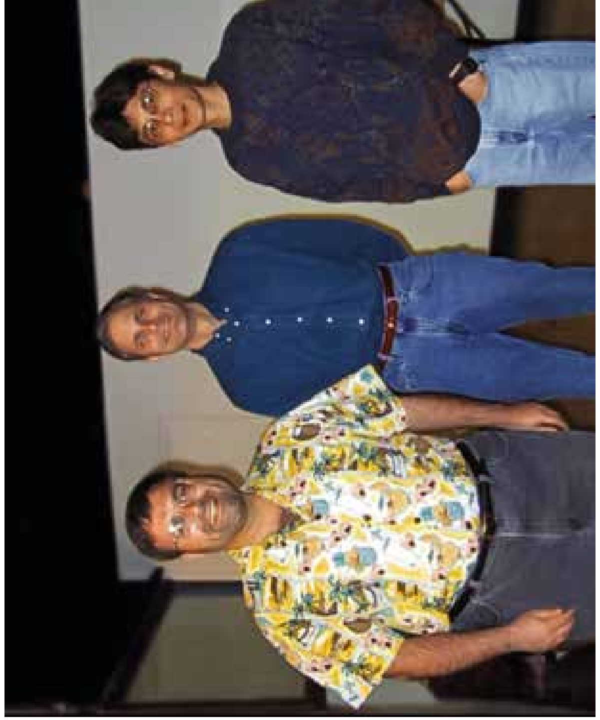
In 2009, the cost of SNP genotyping was half the price of other methods such as microsatellite genotyping. This created an opportunity for collaboration between cattle genomics consortia and cattle geneticists to develop genomic products at a lower price. Microarray technology allows for the testing of thousands of genetic variants at once in a highly accurate manner. Still, SNP arrays remain increasingly affordable as manufacturing is scaled up and other types of SNP arrays such as lower-density chips for regular genetic assessments are developed[22].

Since 2007, large numbers of dairy cattle have been genotyped mainly with the BovineSNP50 BeadChip[23]. Genotypes obtained from these chips are used in association studies to identify loci that affect traits of interest such as milk productivity, heat or microbial resistance, or to obtain more reliable breeding values when the cows are younger to enable more targeted genomic selection of animals. This is what is called “genomically enhanced breeding values” (GEBV) which is now routinely used in several breeding programs worldwide.

In the words of Hallam Stevens, historian of technology, “‘seeing’ or analysing a genome […] requires automated sequencers, databases, and visualization software”[24]. This computerisation of biology has largely contributed to the scaling up of agriculture by producing international standards and reducing generation intervals by rapidly producing high genetic merit calves. These technologies draw biological objects into new relationships, new topologies”[25]. From this perspective, the various datasets on which the BeadChip are constituted inform how these technologies select biological objects and how lines are drawn between beings, practices and goals.

<u>THE COMPANY BEHIND THE TECH</u>

These genomic technologies do not come out of nowhere but are socially and materially grounded. Illumina Inc develops, manufactures and markets integrated systems for the analysis of genetic variation and biological function.



Tony Czarnik, John Stuelpnagel and Mark Chee at their Illumina office in the Summer of 1998.

In the early 1990s, Larry Bock, a biotech investor, and his associate John Stuelpnagel, a veterinarian-turned-Master of Business Administration (MBA), witnessed a promising use of a self-assembling bead technology invented by David Walt at Tufts University, originally used for “optical noses” (odor-detecting bead arrays). This technology could be used as DNA microarrays for mass production.

Illumina Inc. was founded in April 1998 by David Walt, Larry Bock, John Stuelpnagel, Anthony Czarnik, and Mark Chee around the core technology of BeadArray, licensed from David Walt. The BeadArray innovation enabled a pivotal shift from sensing optics to scalable DNA microarrays and, ultimately, high-throughput sequencing. After going public in 2000, the company rapidly expanded and positioned itself at the forefront of sequencing technology through acquisitions of, for example,the Cambridge based company Solexa 2007. In an article published in the MIT Journal on February 18th, 2014, Eilene Zimmerman noticed how Illumina was already at the top of genome business:

> The San Diego–based company sells everything from sequencing machines that identify each nucleotide in DNA to software and services that analyze the data. In the coming age of genomic medicine, Illumina is poised to be what Intel was to the PC era—the dominant supplier of the fundamental technology.[26]

By providing the hardware infrastructure necessary for genomic medicine, Illumina already held 70% of the market at the time, especially thanks to their strong acquisition strategy. Illumina also bought a company called Verinata Health, which has developed a noninvasive prenatal sequencing test to identify fetal abnormalities, obtaining “a service that consumers can buy (through their doctors), in a market that could be worth billions of dollars in revenue”[27]. Illumina provides fundamental sequencing technologies and services for genomic knowledge in a time when genomic information is being introduced into the practice of medicine and everyday life. Their strategy is thus interlaced with the deepening of clinical knowledge in such a field. In the words of Illumina CEO Jay Flatley, “It’s one thing to say, ‘Here’s the genetic variation.’ It’s another to say, ‘Here’s what the variation means.’”[28]

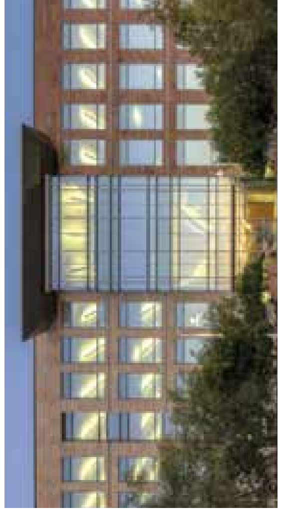
Illumina’s technology is accompanied by the production of biological data to be interpreted. The development of Illumina precisely follows the logic outlined in 2013 by Hallam Stevens as key to the evolution of bioinformatics:

> Both the technology and the science itself can be said to be driven by data. Each provides a further justification for the other: we need more and faster sequencing technology so we can amass more data, and we need the statistical techniques of data-driven science in order to digest those data into useful knowledge. So bioinformatics and next-generation technologies go hand in hand and stand in a relationship of mutual causation.[29]

Sequencing machines are progressively being pushed by hospitals and companies like 23andMe, promoting and selling personalized genomic tests to then retrieve and sell results as data. This market is shaping biological knowledge by introducing increasingly more efficiency into biological and medical practices which in turn makes organic materiality interchangeable with data.

Illumina produces a reliable network with its hardware and with the products which are sold for data analysis. This model condenses the sequencing pipeline with technological innovation. Genomic selection for cattle livestock is the direct result of the intersection between technology and science. Illumina contributes to the genomic evaluation of dairy cattle by bringing new genomic products on the market, partnering with research and industry. Genomic technologies (in large part manufactured by Illumina) allow more precision in selection, making mediums such as high-density SNP arrays and statistical techniques available (both of which are manufactured by Illumina).

In 2016, the San Diego-based company scaled up even more and represented 90% of DNA sequenced data in the world. The company started a new venture called Grail[30] which was backed, among others, by Jeff Bezos, Bill Gates and Google specialised in multi-cancer early detection tests. Today, Illumina and its technologies are compared to other big tech behemoths:



Illumina Inc. Main Building, 5200 Illumina Way, San Diego, CA 92122, United States, ©Illumina

> In the early days, the big moneymakers were the hardware makers like Cisco, which built the fast, reliable network. Then came the companies, like Google and Facebook, whose products are built on top of that fast, reliable network. Illumina has a shot at doing both: build the hardware that makes DNA sequencing fast and cheap so more genetic tests become accessible, and then sell those tests.[31]

Illumina managed to break down the prices of DNA sequencing for a substantial advantage accompanied by services and accessible genetic products. The company even provide an "app store for genetics" where users can browse various DNA tests[32] ranging from ancestry to nutrition[33]. Beyond the glass door of smart-acquisitions, high-quality biotech manufacturing, and strong marketing strategies, Illumina is also known for their aggressive litigation. As described by the MIT Technology Review, "gene-sequencing giant Illumina is like the Standard Oil of the genome age. Except instead of oil it pumps DNA"[34]. In 2016, for example, they sued Oxford Nanopore Technologies for patent infringement over a handheld sequencer — the MinION — which, in reality, did not directly compete with any of Illumina's technologies[35]. The consequence of this aggressive market behaviour is the loss of access to Nanopore products and the closing of research possibilities by creating a monopoly which various researchers have feared[36]. Two years later, the company opened a new shiny campus in Silicon Valley, following in the footsteps of tech giants like Apple, with the aim of attracting highly qualified scientists[37] to the controversial international biotech market. Not only does Illumina mimic Silicon Valley aesthetics of hypervisiblity in elements of the infrastructure[38], they also imitate the design of their workspaces.

Whether behind the glass doors of its headquarters in San Diego, on their campus in the Silicon Valley, in their research and development centers in Singapore, Tel Aviv or Shanghai, or in all their commercial offices throughout the world, Illumina is progressively building a whole technological infrastructure around the manufacture of microchips and genomic hardware, which facilitate the transfer of information in the form of electric signals.

The shaping of knowledge using technological instrumentation, particularly with statistics and computer instrumentation, has progressively transformed scientific practices. Illumina has become one of the major actors of this transition. 'Bioinformatics' or 'computational biology' are interdisciplinary sets of practices adding new intermediaries and new power relations in the scientific processes of interpretation, knowledge production and intervention. At the core of genomics lies the enhancement of prediction power, a technique for controlling what is yet to come, with different prediction outcomes depending on the quality of the input data and the goals embedded in algorithmic projections applied to bodies. In its small yet complex form, the BovineSNP50 BeadChip crystallizes this transformation. It is simultaneously a material object made of silica beads, a market infrastructure for the standardisation of cattle into comparable datasets, and a social and political device to determine which traits matter, and which cows have value. The BeadChip was a key tool in turning cows into operational datasets. This technology has since then been continuously upgraded and expanded in newer products engaging with various cattle datasets, transforming bovine lives through layers of hardware, software, scientific programs and corporate strategy.

1 Everlyn M. Rusly, "Attempting to Code the Human Brain. Startups, Tech Giants Expand World of Artificial Intelligence; Software With an 'Imagination'", *wsj.com*, February 3, 2014, https://www.wsj.com/articles/SB10001424052702304851104579361191171330498.

2 Vicarious is an AI software start-up supported by several Silicon Valley's major investors such as venture firm Founders Fund, cofounded by Peter Thiel, Mark Zuckerberg, Elon Musk, and Jeff Bezos. Alphabet Inc. acquired the company in 2022. Will Knight, "Inside Vicarious, the Secretive AI Startup Bringing Imagination to Computers", *MIT Technology Review*, May 19, 2016, https://www.technologyreview.com/2016/05/19/160125/inside-vicarious-the-secretive-ai-startup-bringing-imagination-to-computers/.

3 Rusly, "Code the Human Brain."

4 "Farm Aid: How Genomics Changed Herd Management", *illumina.com*, August 8, 2019, https://www.illumina.com/science/customer-stories/icommunity-customer-interviews-case-studies.html

5 Jennifer Gabrys, *Digital Rubbish, a natural history of electronics*, (The University of Michigan Press, 2011), 24.

6 Gabrys, *Digital Rubbish*, 8.

7 Morris Soller, Jacques Beckmann, "Genetic polymorphisms in varietal identification and genetic improvement.", *Theor. Appl. Genet.*, 67 (1983): 25–33; Jacques Beckmann and Morris Soller, "Restriction fragment length polymorphisms in genetic improvement:
methodologies, mapping and costs", *Theor. Appl. Genet.*, 67 (1983): 35–43.

8 James E. Womack, "First steps: bovine genomics in historical perspective." *Animal genetics* vol. 43 Suppl 1 (2012): 2-8.

9 Morris Soller, "If a Bull Were a Cow, How Much Milk Would He Give?", *Annual Review of Animal Biosciences*, 3 (1) (2015): 1–17.

10 Jon Hamilton, "Cows Achieves Fame Through her DNA", *npr.org*, April 23, 2009, https://www.npr.org/2009/04/23/103382511/cow-achieves-fame-through-her-dna

11 Diana Yates, "What makes a cow a cow? Genome sequence sheds light on ruminant evolution.", *University of Illinois Urbana-Champaign*, April 23, 2009,
https://news.illinois.edu/what-makes-a-cow-a-cow-genome-sequence-sheds-light-on-ruminant-evolution/

12 David W. Burt, "The cattle genome reveals its secrets", *Journal of Biology*, 36, 2009.

13 This is called marker-assisted selection (MAS). James E. Womack, "First steps: bovine genomics in historical perspective." *Animal genetics* vol. 43 Suppl 1 (2012): 2-8.

14 Will Fiske, "The Chosen One", , "The Chosen One. How a single cow and the Hereford breed continue to impact the world", *Herford.org*, April 2023.

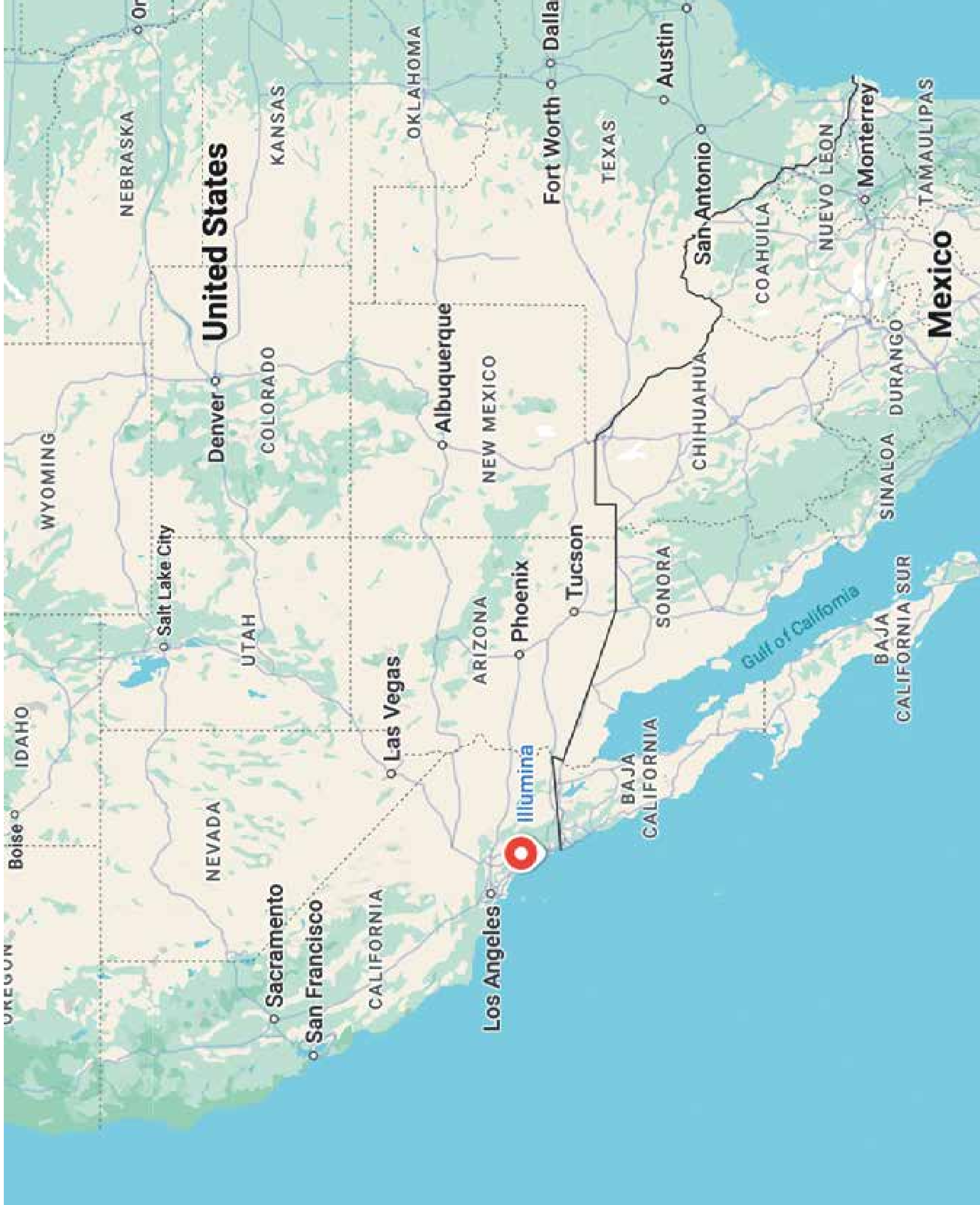
15 Simon Vanderstraeten, Jenske Bal, François Thoreau. "In search of the 'flexible cow': Valuation practices and bodily limits in cattle livestock selection and reproduction." In *Value Economy* (eds. Asdal, K & Dogonova, L.), (Mattering Press, forthcoming).

16 Morris Soller, "If a Bull Were a Cow, How Much Milk Would He Give?", *Annual Review of Animal Biosciences*, 3 (1), (2015): 15.

17 Shawna J Zimmerman et al. "An empirical comparison of population genetic analyses using microsatellite and SNP data for a species of conservation concern." *BMC genomics* vol. 21,1 382. 1 Jun. (2020).

18 Technology Networks, "Illumina to Develop iSelect Bovine BeadChip with Three Collaborating Institutions", *technologynetworks.com*, August 25, 2006, https://www.technologynetworks.com/genomics/news/illumina-to-develop-iselect-bovine-beadchip-with-three-collaborating-institutions-197804.

19 Cluster generation is where the separated strands are copied millions of times to produce a larger sample.
20 Illumina also manufactures genotyping machines such as the iScan System.
21 BovineSNP50 BeadChip Documentation.
22 Navid Ghavi Hossein-Zadeh, “An overview of recent technological developments in bovine genomics”, *Veterinary and Animal Science*, Volume 25, September (2024).
23 Chris Schrooten et al., “Error rate for imputation from the Illumina BovineSNP50 chip to the Illumina BovineHD chip.”, *Genetics, selection, evolution*, 46. 10., (2014).
24 Hallam Stevens, *Life out of sequence: a data-driven history of bioinformatics* (The University of Chicago Press, 2013), 4.
25 Stevens, *Life out of sequence*, 11.
26 Eilene Zimmerman, “50 smartest companies: Illumina on Top”, *MIT Technology Review*, February 18 (2014), https://web.archive.org/web/20150905084140/http://www.technologyreview.com/featuredstory/524531/why-illumina-is-no-1/.
27 Zimmerman, “50 smartest companies”.
28 Jay Flatley, CEO of Illumina from 1999 to 2016, quoted by Eilene Zimmerman. Zimmerman, “50 smartest companies”.
29 Stevens, *Life out of sequence*, 206.
30 John Battelle, “Chasing The Grail: Bill Gates, Jeff Bezos, Illumina, and Google Ventures Are Betting This Company Will Find A Cure For Cancer”, *medium.com*, June 1, 2016, https://medium.com/newco/chasing-the-grail-bill-gates-jeff-bezos-illumina-and-google-ventures-are-betting-this-company-6211cf2e086e.
31 Sarah Zhang, “Illumina, the Google of Genetic Testing, Has Plans for World Domination”, *wired.com*, February 26, 2016, https://www.wired.com/2016/02/gene-sequencing-goliath-wants-get-bigger-still.
32 See: https://www.helix.com. Read more: Megan Molteni, “Helix’s Bold Plan to Be Your One Stop Personal Genomics Shop”, *wired.com*, July 24, 2017, https://www.wired.com/story/helixs-bold-plan-to-be-your-one-stop-personal-genomics-shop/.
33 Lydia Ramsey Pflanzer, “A DNA-testing startup just launched an ‘app store’ for genetics”, *Business Insider*, July 24, 2017, https://www.businessinsider.com/helix-launches-app-store-for-genetics-2017-7.
34 Antonio Regalado, “With Patent Suit, Illumina Looks to Tame Emerging British Rival Oxford Nanopore”, *MIT Technology Review*, February 24, 2016.
35 Zhang, “Illumina”.
36 Kelly Servick, “Amid patent lawsuit, genetic sequencing upstart unveils new technology”, *science.org*, March 8, 2016, https://www.science.org/content/article/amid-patent-lawsuit-genetic-sequencing-upstart-unveils-new-technology.
37 Megane Molteni, “Biotech Gets Some Silicon Valley Shine at Illumina’s New Campus”, *wired.com*, April 19, 2018. [Online: https://www.wired.com/story/biotech-gets-some-silicon-valley-shine-at-illuminas-new-campus/]
38 Jennifer Holt and Patrick Vonderau, “Where the Internet Lives. Data Centers as Cloud Infrastructure”, in *Signal Traffic. Critical Studies of Media Infrastructures*, ed. Lisa Parks, Nicole Starosielski (University of Illinois Press, 2015): 71–72.



WHERE IS THE DOUBLE MUSCLE GENE ?

SIMON VANDERSTRAETEN

In this small text, I propose to dwell for a moment on the **etymology of the concept of the "gene".** The word, coming from "genesis", designates the origin of something. History of science has long taken this origin as a clear and fixed start and tended to forget about the **verb** behind the word. For something or someone to originate it needs to be generated. Genetics, I argue, would better be understood as the science focused on **processes of generation**. The gene is not reducible to any kind of unique molecule, it's an operation, **the act of generating a living being**.

I want to test this idea with the case of the **"double-muscle" gene** which can be found in the genome of **Belgian-Blue cattle**. But is it possible for a small locus on a genome to generate a physical characteristic all by itself? That's what I want to explore.

Since its first coinage at the beginning of the century, the word **"gene"** has never stopped triggering strong and passionate debates about its meaning and origin. Every history of the concept has its forefathers — sometimes, more scarcely though, its foremothers — depending on the narrative tint one wants to expose. Sitting in the genetic pantheon are characters such as Charles Darwin, Gregor Mendel, Hugo De Vries, Thomas Hunt Morgan, James Watson, Franis Crick and more rebellious, hidden — or made invisible — figures like Rosalind Franklin, Barbara McClintock and Lynn Margulis. The gene has had as many definitions as the number of people in this list.

When recounting the history of genetics, the most common storyline starts around the second half of the 19th century with **Mendel** and his search for "hypothetical factors responsible for differences in phenotypes."[1] Although Mendel never used the word "phenotype", his meticulous research had nothing to do with genes either, at least in the way we understand it now. The Moravian monk was a plant geek, but he wasn't searching for genes, he was studying the **laws of hybridity**. The story of Mendel's gardening research is better understood in the context of the Abbey of St. Thomas and its abbot, Cyrill Napp.

Napp was engaged in numerous debates about inheritance with breeders' groups. His main question, "What is inherited and how?" concerned apples, bees, sheep and vines[2]. Napp, immersed in these very practical breeding problems, gave Mendel the pea garden so he could help in this research by focusing on the cases of hybrids. Mendel's concern lay with physical traits and the way they interact with each other in the course of inheritance. Here, the gene intervened to bear the internal and hidden responsibility for these traits. **Mendel's gene is therefore**

the name of an operation. He only had to conjecture the gene as a responsible factor for the combinatory result of his laws of heredity.

The modern life of the concept started with a very different question, when Thomas H. Morgan asked **"Where?"**. The American embryologist embarked with all its drosophila from the 'banana lab' (one needs to attract the tiny fruit flies, and bananas, as everybody who ever had a fruit basket in the kitchen knows, do a very good job) on a quest to locate the atom of heredity. This colorful method led to the definition of the **chromosomes** as the bearers of genes and offered them a place to live. This moment, along with the double-helix model that would follow a few decades later, was pivotal for the gene as it started its existence as a **material entity**.

Genes shifted from an operative entity into actual matter through **the act of locating**. To understand this event, we must go back to the modern definition of matter given by Descartes. In his famous dualist proposition, reality is divided into two substances: matter and thought. The division between the two is marked by the concept of extent *(res extensa)*: **a matter is defined by its necessary location in spatial extension**. While matter can thus receive spatial attributes, thought *(res cogitans)* cannot.

In modern cartography derived from that definition, the question "where?" therefore acts as a vector of reification; it has the power to turn a *res cogitans* into a *res extensa*. In our case, it **compels the gene to find a place in the material grid of a *res extensa***. What came out as a rather abstract entity in Mendel's case (or a "temporary hypothesis" in Darwin's case[3]) became a material thing that consequently had to be somewhere. First on the chromosomes, then within DNA molecules as a combination of nucleic acids.

AND NOW WHERE?

Let's take this modern legacy's questioning and twist it with the help of a massive ally: the Schwarzenegger of the cows, more commonly known as the **Belgian-Blue breed**. This bovine type is famous for displaying a morphology of excess, particularly on the back legs and butt muscles, which earned them the French adjective 'cularde', literally meaning 'from the butt'. Belgian-Blue cows and bulls have been pure bred to enhance the **'double muscle' trait**, a muscular hypertrophy that makes them the champions of the carcass-weight ratio. This double muscle trait started as an anomaly, a monstrous anatomical defect that could cause harm to the animals and should have been halted right away. The defect probably would have been eliminated without the butchers who saw the potential for meat accumulation. It was therefore maintained and selected throughout generations and became an official criteria for the breed in 1973[4].

Now this morphological characteristic has a classic genetic history. It captured interests as a physical trait to be enhanced for the benefit of meat cultivation. It was only a bodily characteristic then, something bulls and heifers might carry and pass on to future generations. Then genetics arrived and **transformed *bodies* into *phenotypes***. A quick etymological search for 'phenotype' identifies the ancient Greek roots 'phaínô' ("to make shine, show, appear") and 'tupos' ("mark", "print", "type").

Allow me to meander for a second here. Could we imagine what the questions of genetics would be if biologists had stuck to the apparently less scientific etymology? Instead of asking "where are the genes responsible for this phenotype?" they would wonder "how does that body shine?"

A term used exclusively in the jargon of genetics, 'phenotypes' gives organisms the property of something appearing. We might ask then, how and from where do these appear? But the word requires lingering for a moment. Having a background in philosophy, I cannot help but have a small bell ringing in my head whenever I come across a term such as **'appearance'**. It is one of the least innocent concepts in Western history. Coupled with 'reality', the two terms mutate into a ruinous war machine against all that is diverse. Appearance brings with it, as Didier Debaise and Isabelle Stengers put it, "the 'horror of becoming a dupe' that William James locates at the heart of modern experience."[5] Positioned in opposition to 'reality', appearance never ceases to cast doubt on everything it touches. Anyone who might wrongly believe something to be true is put at risk of being a fool. Appearance has produced a large number of naïve people across history: the Athenian non-philosopher who happened to be stuck in the Platonic cave, the medieval peasants who saw a wave of the divine in the malformation of a newborn, the troll believers, those who fear entering the woods at night, those who walk in jungles saturated with animal spirits, those who recovered from a disease thanks to witchy intervention…

…and these farmers who rely on morphological traits for their breeding choices. **The invention of the phenotype was the best tool for genetics to ensure a legitimate grip upon bodies**. Placing what is seen bluntly through the eyes in the realm of appearance secures a royal pathway toward reality, now defined as genotype.

With the deployment of genetic tools in farming practices, the source of knowledge about animals has become a battleground. While breeding practices have historically developed through visual techniques and knowledge based on long-time observation of animal behaviors and morphology[6], **geneticists provide a new gaze** which pretends to bypass all this visual context in order to disclose directly what's hidden "under the skin"[7]. The sequencing machine has replaced the Platonic eye of the mind in its task of piercing through the now fleshy veil of appearances. Although this gesture of replacement does not operate smoothly, freed of bargaining or conflict[8], it nevertheless reshapes the ontological claim about the animals: their truth lies in their genotypes.

Believe in the phenotype, at least! but the body, that's mischieving.

The double-muscle trait's history is no exception to this trend. The breeding pace of the Belgian-Blue cattle quickened once the gene responsible for the hypertrophy had been disclosed in the 1990s[9]. Operating a sweep through the bovine genomes, a team led by M. George and R. Hanset found the loci deemed responsible for the double-muscle trait and soberly called it the ***mh* gene**, for *muscular hypertrophy*. This discovery unlocked the possibility of a marker-based selection, strengthening the 'culard' in every generation as the cows grew larger and larger. The calves are now so big it is almost impossible for a cow to give birth without a caesarian section. As the animals continue to inflate, they start to swell in public debates too, triggering various concerns about animal welfare. Switzerland even banned the pure breeding of the Belgian-Blue breed under the contention that the enhanced deformity alters natural development and can cause constant pain to the animals[10].

Nonetheless, these **excessive morphologies** nowadays are reaching some practical **limitations**. Can the muscles continue to enlarge endlessly? We asked this question once to a former bovine fattener. "If you want more of it", he answered, "you'll need a fifth leg, otherwise it'll crack." Concerning body plasticity, this answer is as clear as you can get.

The Belgian-Blue is not the first domestic species to trigger such amazement and repudiation though. The very process of domestication itself has always produced

similar debates, under the assumption that it was nurtured by a certain "human propensity to deform":

> Highly bred domestic animals, whether the prize livestock whose staggering obesity inspired the admiration of agricultural improvers, or the pet collies and bulldogs whose muzzles had been elongated or compressed for the delight of fanciers, were criticised as "not in fact perfect animals, but monsters, i.e., deviations from, or modifications of, the natural type of the species." William Henry Flower noted that "the power which . . . has led to the vast improvement seen in many domestic species over their wild progenitors has also ministered to . . . the perpetuation of monstrous forms"; he attributed this wilful hereditary distortion to an innate human "propensity to *deform*", which also caused people to dock the tails of horses, crop the ears of dogs, and encase their own feet in pointed shoes and their thoraxes in tight corsets.[11]

With the Belgian-Blue, breeders have now reached the body's limits and cannot do much more to inflate their 'staggering obesity'. In dealing with the impossibility of a five-legged cow, farmers and breeding companies are now turning to the vocabulary of flexibility[12]. However, given the amount of muscle one can find concentrated within a single animal, we are forced to wonder: *how does the animal hold at all? Are we so sure there's no fifth leg hidden somewhere?*

We need to take a detour to answer this question. In the above mentioned quote, William Henry Flower spoke of a 'human propensity to deform' to qualify processes of domestication. We might look closer at this assumption and get rid of the moral tinge that clings to it. This story is indeed about deformation, or rather just about formation. It is about the form species impose on each other while interacting, although in asymmetrical ways. In her text about Michel Serre, Vinciane Despret examines this question through an inquiry of the word **'trait'**[13]. In French, a trait defines both a physical/behavioural characteristic and the quick drawing of a line. The word has also gathered a great legacy in genetics and has secured a place in the discipline's dictionary. Indeed, a common determination of the gene defines it as a nucleic acid chain responsible for the generation of a phenotypic trait. According to Serres, though, the **trait is much larger** than the unidirectional result of a situated part of DNA. Whether we are talking about stars, bacteria, humans, or rocks, we always rely on the same language: that of traits and their mutual effects[14]. Things exchange shapes, weighing on one another, borrowing from each other, stealing and tearing pieces off of each other:

The language of the world, which articulates multiple powers of action, can be described in terms of traits: traits that trace different writings of things and beings on each other, traits of attachments and attractions that attest to the fact that **the things of the world comprehend each other.**[15]

“Things of the world comprehend each other”, said Despret. ‘Comprehension’ must be understood with its etymological background: ‘to grasp with’. When she uses “comprehension”, she thus indicates that things of the world contain each other in the sense that they are shaped by the very action of grasping one another. The profile of a cliff comprehends the history of the ocean and the power of the waves. Water written on rocks.

Turning our attention back to the Belgian-Blue, we are now compelled to ask: *what things comprehend these cows?*

In the 1970s, the herdbook managers decided to give a determinate meat orientation to the selection process of the breed. Still, the high carcass-weight yield provided by the Belgian-Blue did not automatically overflow the market. It took some time and transformation to accustom the Belgian palate to this novel product. A whole marketing had to be put in place to advertise a **new culinary norm, that of the lean and tender**. “Instead of tough cuts that can only be softened by cooking for a long time, we prefer ‘noble’ cuts, without fat or fascia, whose tenderness is enhanced by rapid cooking.”[16] The entire meat infrastructure consequently reconfigured itself around this new creed:

> Butchers demand carcasses with a higher proportion of “noble cuts”, which are more expensive on the shelves; breeders sell their ultra-conformed animals more effectively; veterinarians take a positive view of Caesarean sections, which have become indispensable; supermarkets are delighted with the potential of this dietary product, which is quick and easy to cook and corresponds to recent changes in lifestyles.[17]

A **socio-economic exoskeleton** was constructed around the Belgian-Blue in those years to support and nurture the breed… until it could not fit the European standard for carcasses qualification (CEE 1208/81) anymore. This qualification

ranks every animal carcass sold on the market from P (poor) to E (excellent) based on shape and the ratio between fat and lean-meat. Belgian-Blue corpses were way too massive to fit in the existing categorisation. A new category, “S” for ‘super-culard’ (now ‘superior’), was therefore added to the EUROP classification, which thereafter became the SEUROP ranking (CEE 1226/91)[18].

It is **tempting to qualify all these components — whether social, culinary, veterinary, economic or legal — as environmental**. But this would be misleading. As soon as we qualify something as “environmental”, it tends to fade away into a blurry aggregate that leaves the ‘centre’ undisturbed. If we consider as the ‘centre’ of our story the Belgian-Blue breed and its specificity, **the *mh* gene is *as responsible as* all the mentioned components in the generation of the double-muscle trait**. Without the butcher’s ability to cut through this tender flesh, without the veterinarian intervention (to which we could add the necessary antibiotics that automatically go along the systematic caesarian section), without the legislation that makes room for the carcass in the market, and without the collective learning to taste and appreciate the lean and tender, the Belgian-Blue could never exist. These are the **breed’s condition of existence** just like the series of nucleic acids hidden within the animal’s cells.

This case illustrates the conceptual rephrasing of Western ontology proposed by Bruno Latour. In his “Inquiry into modes of existence”, Latour engages with the Western metaphysical tradition which posits the concept of being as a fixed, immobile substance. He qualifies this tradition as the **‘being-as-being’**; one, where ‘to be’ means to stand alone and for oneself. Latour challenges that idea with the concept of **‘being-as-other’**, a being which, by definition, cannot stand alone on its substance and necessarily has to go through several others in order to exist[19]. Existence has never been a matter of purity, it is a messy business. It is better described by the word ‘consistency’ (etymologically, ‘to stand with’), which insists on relations rather than substance (‘to stand under’). Beings do not owe their existence to a fixed substrate but to other beings with whom they stand.

Our Belgian-Blue is the perfect illustration of a being-as-other: it has to travel through several other beings, entities, or events (the butchers and their cuts, the vets and their ceasections, the European norm, etc.) to exist as the animal breed it is. **These not-so-external elements actually shape the fifth leg, even the sixth, the seventh, and many more without which the animal could not stand.**

After this ontological bracket, let me tell you a joke. It is quite a common one in the physicists' world[20].

There once was a farmer who experienced some trouble with his milk production level. He went to a group of physicists and asked for help, to which they gladly accepted. The scientists came to the farm, collected all sorts of data and went back to their laboratory cave to craft a solution. After a while, the lead researcher came back to the farm, filled with pride and satisfaction. He announced: "We found the answer. Let's start by assuming **a perfectly spherical cow in a vacuum**."

If you are not a physics geek or a fan of the TV show "Big Bang Theory", you might not perceive what is funny about this. The joke relies on a physicist's habit to reduce every problem to a bunch of mathematical variables. Once duly reduced, every situation offers what they call **symmetry**: "When a system has symmetry, there is an associated conserved quantity, a property of the system that doesn't change with time even as the system evolves."[21] In other words, if a cow were perfectly spherical, it would be symmetrical. You could then turn the animal upside down and it would not change the fact that what is correct for the left side is exactly the same as the right one. A spherical cow in a vacuum would produce the same amount of milk whatever the environment. It is a lab cow, a standard animal on which one could test all different variables without bothering with the 'noise' of complexity.

We may provocatively argue that this **spherical cow in a vacuum is genetics' wildest dream**. The nucleic acids and their universality provide biology with something close to symmetry: they are supposed to stay identical to whatever living being they find themselves in. Although we would surely obtain a result similarly as absurd as a spherical cow with the reduction of a being to its atoms of DNA. As John Dupré reminds us: if you try to throw away DNA strands in a bin, the bin will not grow blue eyes[22]. **The gene does not generate anything by itself**. Nevertheless, the dream of these biological atoms being transposable remains vivid in the recombinant DNA sector under the name of **modularity**:

> A key requirement for the reduction of complexity is the assumption of modularity. Modularity is not a straightforward concept, but in engineering terms, a module is defined as 'a functional unit that is capable of maintaining its intrinsic properties irrespective of what it is connected to' (Sauro, 2008: 1). Modular entities are very important in engineering because they can be extracted from one part of a system and inserted in another with no change in their function (Sauro, 2008).[23]

Genes being transposed from one organism to another are supposed to produce the same effect they used to in their former body. Modularity is often confused with an intrinsic quality of DNA, bypassing all the work and complicated operations needed to produce it in the first place. As Jane Calvert recalls, this confusion has been a major argument in the GMO debates with advocates pretending to do nothing more than repeat the gesture of engineering already at work in nature.

The concept of modularity in question here displays identical features as those of the '**nonsoels**' described by Anna Tsing. In her work on scalability, she describes the ways in which living things such as trees are standardized in their shape, growth rate, feed intake, and so on, in order to be exchanged internationally and planted on any ground. This process is why one can find the exact same tree (a palm tree for instance) in two different continents. In order to live and render independently from the specificity of a given ecology, the tree has to be cut off from the complex relations it depends upon. The emerging descriptor, "nonsoels", can equally be applied to mushrooms or cows.

"Elements of the social landscape removed from formative social relations might be termed 'nonsocial landscape elements' or, using the pixel formula, 'nonso' plus 'el' or nonsoels."[24]

Tsing exhorts caution regarding the bad reflex of ascribing to nature a quality that actually requires work and transformation to be produced. 'Nonsoels' need to be actively engineered, one ought to cut or abstract them from all their social relations before they can travel without transformations.

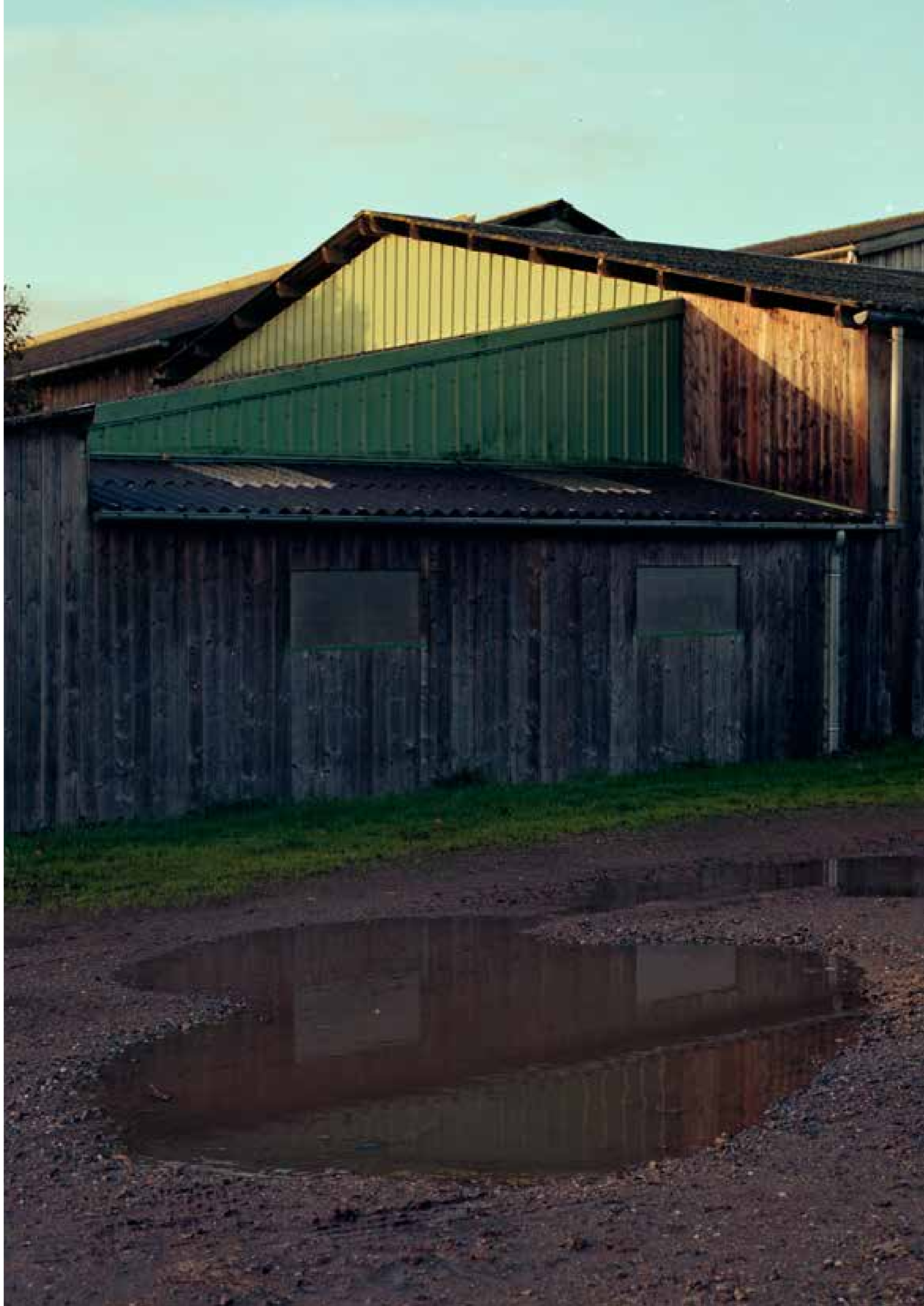
With this in mind, we can come back to our bovine muscular hypertrophy. To answer the question **"where is the double-muscle gene?"** by pointing to the *mh* gene is to repeat the dream of modularity. **The gene is an intrinsic non-nonsoel, it needs an entire landscape in order to thrive**. Therefore, if we come back to the operational etymology of the gene as something defined by its action of generation, we are entitled to say that the double-muscle gene is the *mh* loci on the DNA, and the lean and tender norm, *and* the veterinarian gestures, *and* the butcher's cuts. It is a ***generative* environment** that offers a distributed version of the gene, one that works through addition —a logic of '*and*'— rather than reduction.

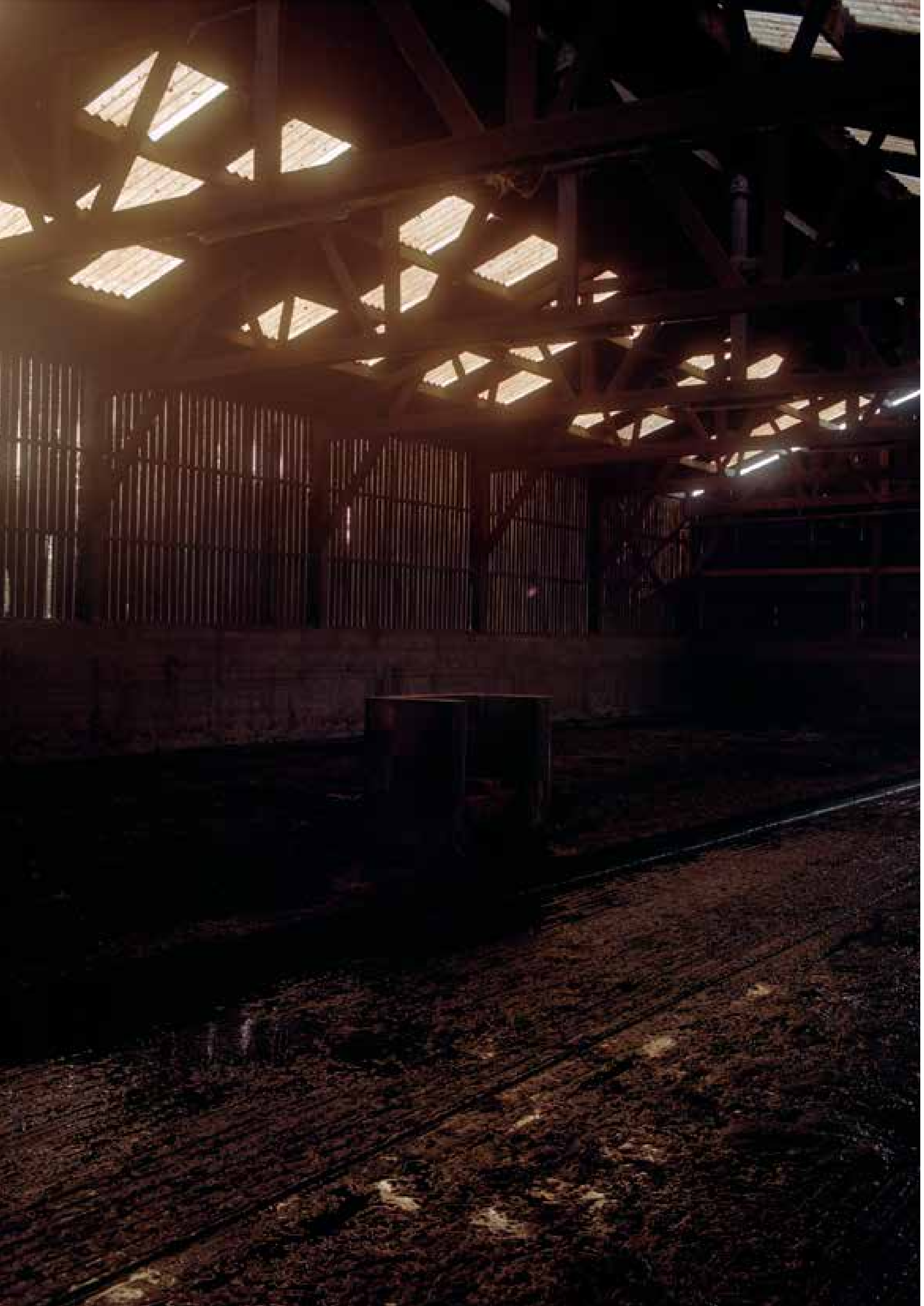
1 John Dupré, “Understanding contemporary genomics”, *Perspectives on Science* 12, no.3 (2004), 325.
2 Gregory Radick, *Disputed inheritance: The battle over Mendel and the future of biology* (University of Chicago Press, 2023), 22. See the “Temporary hypothesis of pangenesis” in Charles Darwin,
3 *The variation of animals and plants under domestication* (John Murray, 1868).
4 Marie Gérard, “Relativiser la ‘transition’, penser la ‘contradiction’,” *GREP* «Pour» 3 no. 231 (2016). Didier
5 Debaise and Isabelle Stengers, “An ecology of trust? Consenting to a pluralist universe,” *The Sociological Review Monograph* 70, no.2 (2022): 403.
6 Cristina Grasseni, “Skilled vision. An apprenticeship in breeding aesthetics” *Social Anthropology* 12, no.1 (2004).
7 Lewis Holloway, “Aesthetics, Genetics, and Evaluating Animal Bodies, Locating and Displacing Cattle on Show and in Figures,” *Environment and planning D: Society and Space* 23 no.0 (2005): 894.
8 Catherine Mougenot et al., “Le ‘coup d’œil de l’éleveur’ est-il menacé par l’élevage de précision ?,” *Activités* 17, no.2 (2020).
Claire Gaillard et al., “Éleveurs et vaches dans l’épaisseur et l’accélération du temps. Quand le progrès génétique n’attend pas,” *Natures, Sciences et Sociétés* 31, no.4 (2023).
9 C. Charlier et al., “The mh gene causing double-muscling in cattle maps to bovine Chromosome 2,” *Mammalian Genome* 6 (1995).
10 https://www.fedlex.admin.ch/eli/cc/2014/747/fr
11 Harriet Ritvo, *The Platypus and the Mermaid, and Other Figments of the Classifying Imagination* (Harvard University Press, 1997), 131.
12 Simon Vanderstraeten et al., “In search of the “flexible cow”: valuing machines and bodily limits in cattle livestock selection and reproduction” in *Value economy*, ed. Doganova Liliana and Asdal Kristin (Mattering Press, t.b.p)
13 Vincianne Despret, “Traits,” *Environmental Humanities* 12 no.1 (2020).
14 Michel Serre, *Darwin, Bonaparte et le Samaritain, Une philosophie de l’histoire* (Éditions Le Pommier, 2016)
15 Despret, “Traits,” 188.
16 Gérard, “Relativiser la transition,” 216.
17 Gérard, “Relativiser la transition,” 216.
18 Pierre-Marie Stassart and Daniel Jamar, “Agriculture biologique et verrouillage des systèmes de connaissance. Conventionnalisation des filières agroalimentaire bio,” *Innovations Agronomiques* 4 (2009), 122-123.
19 Bruno Latour, *Enquête sur les modes d’existence, Une anthropologie des modernes*, (La Découverte, 2012)
20 Chandra Prescod-Weinstein, *The Disordered Cosmos; A Journey into Dark Matter, Spacetime, & Dreams Deferred* (Bold Type Books, 2021a).
21 Prescod-Weinstein, *The Disordered Cosmos*, 21.
22 Dupré, “Understanding contemporary genomics”, 325.
23 Jane Calvert, “Synthetic Biology: constructing nature?,” *The Sociological review* 58, no.1 (2010): 98.
24 Anna Tsing, “On Nonscalability: The Living World Is Not Amenable to Precision-Nested Scales,” *Common Knowledge* 18, no.3 (2012): 508.

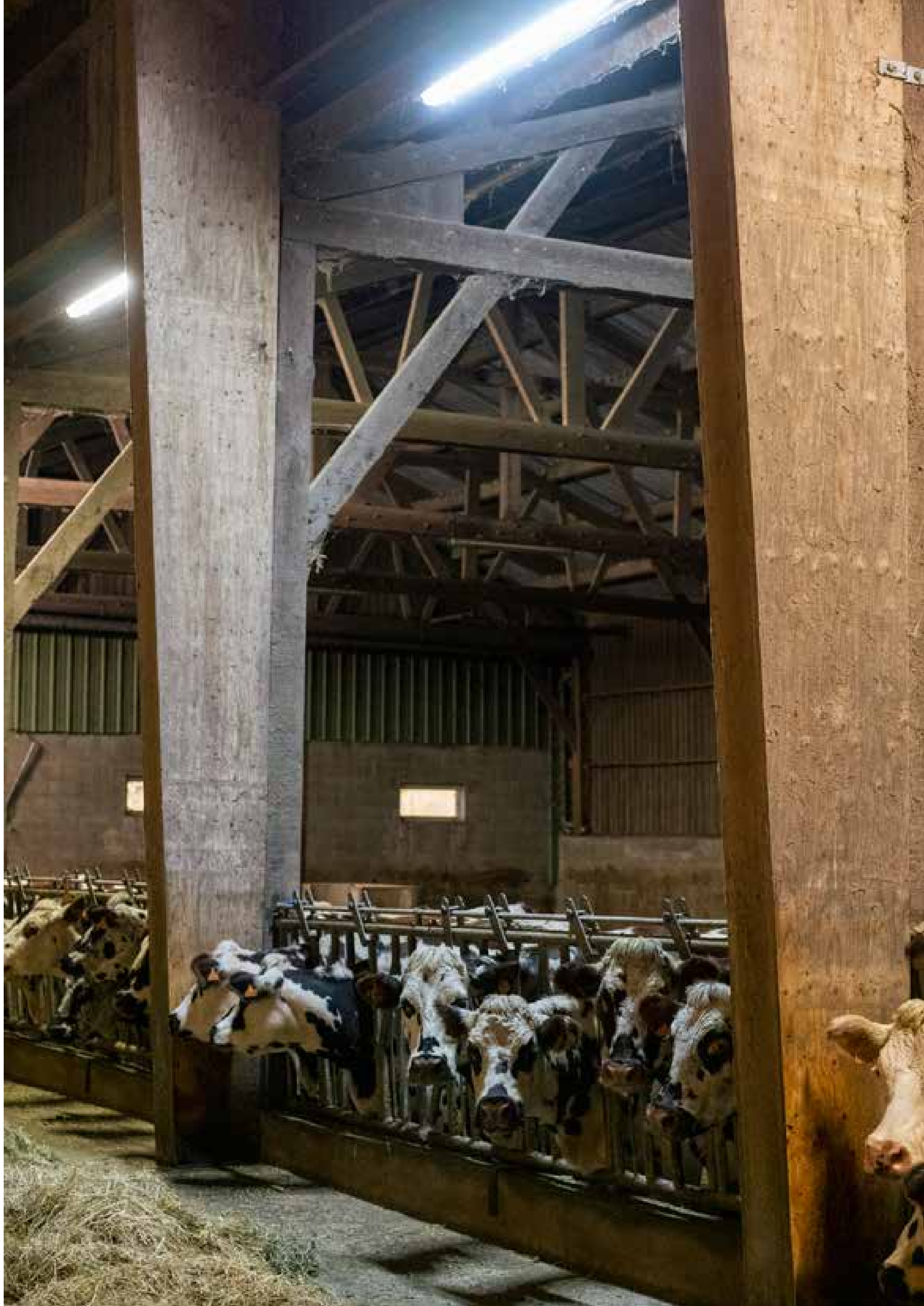
Général de l’Ecluse, Belgian Blue bull, 1307kg, November 19, 2019, Belgium, blanc-bleu-belge.com

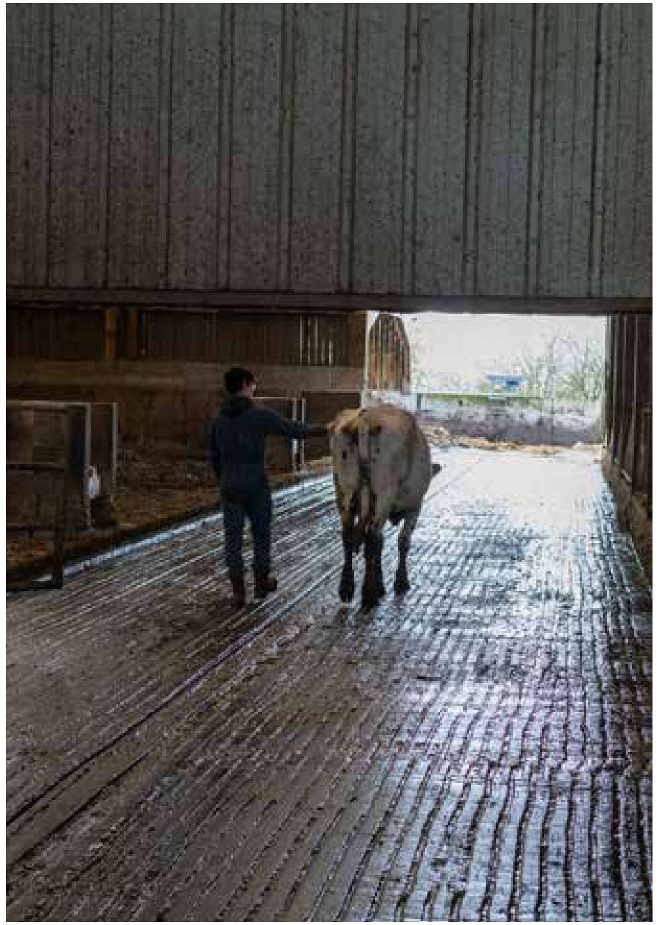
PICTURES FROM THE FIELD

TÉO BECHER






INHERITING FROM AURORE B. ON THE TRACES OF THE "COW OF THE FUTURE"

ROXANE GABET SEVERNE

This photograph, taken by Téo Becher, is a watering trough in a field, taken at twilight.

A fable for tomorrow:
"The Cow Who Sang a Song Into the Future"[1]
Part 1

Once upon a time, Mrs Borealis grazed peacefully among passers-by. Everyone recognized her at once. Her coat, which shaded from dark grey to chalky white, glowed with such intensity that people had to squint under the sun's rays — a sun that was also shining brighter and longer than ever before. Above all, it was her eyes that made her so attractive. A happy crossbreeding with her ancestors Thames, Passionflower, and Wisdom had given them a smoky look. Some even said that she had the radiance of Aurore B., whose story had since spread beyond the borders of Mayenne, inspiring poets, geographers, ecologists, biologists and other bovine enthusiasts. Let us tell it one more time.

My inquiry is based on the traces of what could be the "cow of the future" or, in the plural, the cows of the futures, as multiple versions are emerging in various places as a response to climate change, and to its rapid and thick temporalities. The question of cows' adaptation to a changing environment has captured the attention of many in the scientific, farming and industry worlds. But there are different ways of "adapting", or making reciprocal adjustments between body and territory. To better understand these, my starting point is to learn how to inherit from Aurore B., because it is a story that links the laboratory and the farm, allowing me to take some detours, with the question of cattle reproduction and the technologies that make it possible as a common thread. I begin with the first lines of a "fable for tomorrow", in the footsteps of Rachel Carson, who opened her book *Silent Spring*[2], with such a fable, a story depicting a lifeless world, damaged by pesticides, to introduce her argument. The rest will follow.

I'm having a coffee at the entrance to the unit. There's a small machine, a kettle and a few mismatched cups. I'll wash mine in the sink of the lab next door: the lights are off, everything looks a bit faded, lacking in shine. After greeting a colleague, apparently the only one present on this scorching July day, we leave the developmental and reproductive biology laboratory for a tour of the buildings. There are several of them, quite long but not very high — everything looks a bit old-fashioned: the historical site of the French Institute of Agronomy was built just after the Second World War. We get out and Patrick tells me about the cows that used to be there, the goats and sheep, the rabbits and a few pigs. You could see them, smell them and hear them. He shows me the empty stalls — which are no longer up to the European standards — and I try to imagine them. The cows' physical absence contrasts with their dematerialised presence: they are present in the form of databases, outsourced to data centers several kilometers away despite the very material consequences the research carried out here has for them.

We enter another building, a mouse-grey prefabricated structure. I encounter a long corridor with several rooms, but first I must put on a gown, mask, and foot covers. The veterinary surgeon points out each room: pre-op room, post-op room, operating room. At the end of the corridor, a new ultrasound machine is about to be tested on an ewe. On the way out, Patrick tells me: "In the heyday of cloning, the early 2000s, late 1990s, after Dolly, there were a hundred or so cloned cows constantly nearby on an experimental farm a few dozen kilometers away… Today there's less and less funding, and animal experimentation is no longer in fashion." With a gesture, he points to the building opposite — an equally old, prefabricated building, where researchers in bovine genetics are housed. "People also think that livestock farming and meat are obsolete." After all, according to the databases, there are a million fewer dairy cows today than there were thirty years ago.

This story started in July 2022 in the outskirts of Paris, in France, at the National Institute of Research for Agriculture, Food and Environment. How did I get here? My entry point into this inquiry on bovine genomic infrastructure was a reproductive biology laboratory, where I observed the work of biologists and geneticists on a project to adapt cattle to climate change. My inquiry in the lab first led me to track down the traces of an absence. I was looking for the body of this "cow of the future" often used to convince investors: what does she look like? Where does she live? What does she eat? The "green cow for tomorrow" — more resilient to heat stress, capable to thrive on poorer roughage, fertile, healthy and productive enough despite the climatic variations — had no body nor territory so far. But she existed in a myriad of traces: I found her in statistical curves of quantitative genetics, crossing meteorological data with milk production data, in blood samples translated into cortisol levels, making it possible to map epigenetic markers linked to heat resistance, or in genome-edited fertilized embryos extracted from cows in "donor stations". But while the cowsheds on the site are empty, the joy is shared when the heifers (from the neighboring farm that rents the meadow) arrive. The "cow of the future" does exist in the form of a distributed body, as a "virtual being". But she appears also in other fissures: on photographs in scientists' offices, on lab doors, on screensavers on computers, in cuddly toys and drawings, and, above all, in the stories that researchers tell. And it is in such stories that one specific character kept coming up: a certain Aurore B…

So, what is a "virtual being"?

This "cow of the future" is quite something! She is dancing on the borders of inexistence, between being and nothingness. She is, most of the time, a virtual being —as the philosopher Etienne Souriau would have it. He argues that "there is more than one mode of existence for all the beings that inhabit the world, and that there is more than one world to host all of them."[3]

There are "imaginary beings" with a very real social existence, subject to our affects (think of Catwoman *or* Alice in Wonderland *for instance), and there are "things" that have the power to maintain themselves in reality (you, me, this book, the chair you are sitting on), as well as "phenomena" that manifest themselves in all their momentary grace (like a fleeting pink cloud as the sun disappears). But virtual beings are like unfinished drafts; like snippets of a conversation overheard at a dinner that become the core argument of your next paper, or a drawing that invites you to continue on to the next few strokes. Virtual beings "introduce a desire of creation in the world"*[4]*. Importantly, all these beings can shift modes of existence, intensify their reality.*

I would argue that the so-called "cow of the future" is a virtual being who is currently conquering a more-and-more real existence —first on paper, in funding documents for research projects and in the media that relay this information, then within laboratories and on experimental farms. These projects revitalize the old Spinozist question: "What can a body do?" alongside Michelle Murphy's precious reminder to also focus on "what can't a body do?" in a profoundly damaged world that alters lives. I take these questions to guide me and try to answer them not only for the cow per se, but as she is always caught in agencements, in a context, a milieu.

We are in Mayenne in the west of France, at the gateway to Brittany. Near the commune of Bazougers, a singular breed of cattle was created at the end of the 18th century. At the time, the nobility of the canton of Bazougers imported the Fribourgeoise breed from Switzerland. This piebald red and piebald black cow, crossed with local breeds such as the Augeronne, gave rise to the Mancelle. Then, in the 19th century, the importation of the Durham breed from England by the nobility of Anjou led to several crossbreeds, giving the Bleue de Bazougers the characteristics we know today: a rustic black-to-blue coat with mottling. The same applies to its cousins, the Rouge des Prés and the Saosnoise, which are descended from the same crossbreeding. The Bleues reached their peak in the 1950s, but only very locally in the canton of Bazougers. They were never officially recognised by the Ministry of Agriculture as they did not meet the Quittet's policy.

Edmond Quittet, Inspector General of Agriculture in the two decades following the Second World War, worked for the Ministry of Agriculture, where he led a policy of "agricultural rationalisation". In 1943, he published the book *Les races bovines françaises* [French cattle breeds], in which he advocated for genetic progress and simplification. According to him, there were too many breeds of cattle in France, and above all, too many unbred or crossbred animals which made up more than a quarter, almost a third, of the national herd. He wanted to keep a maximum of fifteen breeds in France, and especially promoted larger ones. In the book, he listed thirty breeds: "How can we envisage the elimination of the others?", he asks, setting aside "technical considerations" and environmental effects: why have a multiplicity of breeds when "man has powerful means of modifying [both environments and animal populations]?"

Quittet did not advocate for a pure and simple ban but rather suggested forms of State-led dissuasion: removing incentives for the undesired breeds, such as participating in competitions, subsidies, premiums for the conservation of breeding stock, or subsidies for zootechnical books on the breed. He also encouraged "active propaganda" for the others, those he wanted to promote. Last but not least, reproduction was to be regulated: undesirables would be excluded. Artificial Insemination (AI) was introduced in France in the post-war period, with the creation of the first cooperatives in 1945. It became a widespread practice from the 1950s and 1960s onwards (particularly through the advent of semen cryopreservation) with 5 million AI procedures in 1960 and 7.8 million in 1969. The keywords of this era were standardization and productivity. Unrecognized cattle were not given a breed code, and their semen was not sold by AI centers. The Bleues de Bazougers continued to be bred at a low intensity, some breeders kept them and had bulls that they exchanged and sold, but little by little they dwindled... numbers fell from around 1600 to just a few in the post-war decades.

Mayenne is also a land of hedged farmland —of bocage— a kind of landscape composed by fields and meadows that are enclosed by talus slopes. In the 1970s and early 1980s, a process of "Holsteinisation" began: a biological and institutional process during which the proportion of North American Prim'Holstein cows in the French herd continued to grow as others, such as the Bleues de Bazougers, continued to decrease. What is particularly interesting is that as the Holstein arrived it became necessary as well to create the conditions to welcome them and thus transform the land for their presence. This coincided with the politics of remembrement [land consolidation] from the 1950s onwards, and more intensively in Mayenne in the two following decades. In short, the remembrement involved the "reorganizing" of agricultural plots for the purposes of modernization and, in particular, mechanization. In order to make way for tractors and rationalize land registry plans, the municipalities, subsidized by the State, brought together scattered and fragmented parcels. With the Napoleonic Civil Code in the early 19th century, turning «common grazing pastures» (*vaine pâture*) into private property, land fragmentation intensified with each inheritance. *Bocage* landscapes were partly formed by this movement of enclosures of the commons. Hedges replaced *vachers* and *vachères* (the cow-keepers), often kids or women, who watched cows all day, sometimes knitting or sleeping while doing so. The result, many decades later, was a division of land that was deemed disorganized and inefficient by the State, that was eager for renewed land reform. This involved enlarging the parcels and very often also bulldozing the hedges and trees that bordered the fields. This was then typically followed by the transformation of meadows into arable fields. With the Holsteins came the arrival of maize and a new triad of "Holsteins — maize — concrete" was born.

The story of remembrement is often told in terms of the influence of the American model and the post-Second War New Deal, selling tractors and fertilizers to a ruined Europe. And while this story is important, there is another genealogy to be added: the law on rural land consolidation dates from 1941, under the Vichy government, and so under the Nazi influence. The first law of remembrement in France had been instated in 1919, after World War I, and had been mostly applied throughout the Eastern region because there had been more destruction from bombing, and thus more reconstructions. Remembrement was therefore at least as much urban as rural. Yet, it had not been applied so much: "At this rate, it would take two millennia to complete! The law of March 1941 allows for land consolidation even against a majority of landowners who do not understand the many advantages of this operation. Fortunately, because this is a matter of life and death for French agriculture" wrote René Dumont, agronomist and advisor to the Government. The law of 1941 caused a drastic change: it created the conditions to make remembrements mandatory much more easily in the post-war period.

Je viens pour me faire remembrer, a farmer announced one day as he entered the room in the municipality where Pierre C., he entered the room in the municipality

Mayenne, aerial photographs. On the left : 1950-1965. On the right : 2016 https://www.geoportail.gouv.fr/carte

where Pierre C., a surveyor for the commune, was working at the time. In French, it means both "I've come to have my land re-surveyed" and "I've come to have my limb reattached". The farmer's arm was amputated up to the elbow and he uttered this sentence while banging his other fist on the table, with an indecipherable smile on his lips. When the surveyor told me this story, over thirty years later, he still was unsure how to interpret it. This man had lost his arm in a farming accident with a machine, refused to accept the planned redistribution of the parcels, and had come to protest. The standard procedure for land consolidation began by assigning each parcel a "quality number" according to various criteria, the surveyor then drew a new plan, producing a system of land equivalence, enabling commensurability, exchangeability, and rapid transformation – which elicited many forms of resistance. From demonstrations to people attaching themselves to bulldozers, from songs and sabotages to appeals to the court, the man in the story is refusing this equivalency. But this story carries with it the semantic power of the very word "remembrement". Re-membrer, the prefix "re" evoking the return (again, anew, back), the Latin *membrum* meaning "part of the body". Body and territory. In English, its close etymological cousin *remember* carries the memory of Old French, *remembrer*: to recall, to reminisce.

In the shadow of the agricultural "revolution", there is a story of violence and destruction of trees, of meadows, of village socialities (such rearrangements have sometimes sown seeds of discord for decades), of rural cosmologies. But it is also, perhaps more ambivalently, a story of amicable agreements, common-sense measures, and agricultural work made easier. Or it is the story of a "feminist revolution" as one inhabitant whispered to me, because, at least for her mother, it meant finally being connected to running water and the arrival of the washing machine, while not walking every day in the muddy trails to faraway fields. Today, some people are talking about "low-noise land consolidation" *(remembrement à bas bruit)* — hedgerows are still being pulled up, but quietly, insidiously, discreetly, without any State authority, on a private basis. The conversion of permanent grassland to arable farming with ploughing, in a context where fewer and fewer farms are getting bigger and bigger, added to the problem of their transmission. These are some of the ingredients of today's agricultural headache. At the same time, we are now witnessing policies of réembocagement that aim at reconstituting this particular bocage landscape by planting more hedges while still losing more trees every year. Still, destruction and repair are rarely symmetrical – a young tree seedling will not replace the ripped old oaks. Which cows will find shade under a dense foliage, or feed on the leaves of white mulberry trees, of ash or lime trees, rather than on maize and imported soy? Yet, here we are.

A fable for tomorrow:
"The Cow Who Sang a Song Into the Future"
Part 2

Once upon a time, around ninety-three bovine generations ago — which corresponds roughly to intervals of a year and a half, and therefore around 140 years ago — some State people decided to classify cows, according to performance and rationalization criteria, into those who could live and reproduce, and those who no longer could. In a bid to modernize the system, they drew up lists and rankings, banned bulls from artificial insemination centers and prevented their semen from being chaffed. In Mayenne, a land of western hedgerows where there were more cows than people, the Bleues de Bazougers gradually declined — so gradually that it was almost too late when a technician at the Institut de l'Elevage, more attentive than most, noticed that there was only a few Bleues left, the most beautiful of which was Aurore. It was the age of cloning, with its promise of identical reproduction — a squared-off elite. That's how Aurore B. was born, on an experimental farm from which she would never leave. The story goes that many visiting scientists were not insensitive to her gaze. One of them, a talented geneticist, even fell in love with her. In no time at all, he took advantage of a meeting with a breeder from Mayenne whose bull's genetic anomalies had led him to his office, to suggest: why not "reconstitute" her? After a few years, Jouvence was born.

In 1999, when cattle genetic diversity concerns grew, the French Institute of Livestock Breeding *(Institut de l'Élevage)* found a herd of Bleues de Bazougers. A bull from this herd, Melchior, was then collected, as well as his son, Valeureux. The best cow in the herd, Aurore, was purchased, but it was not possible to breed her, as she was already very old — she was fifteen at the time. So, she was entrusted to the Institute of Agronomy, where scientists took a biopsy of cells from her ear, in extremis, before she died at the age of seventeen. From this small piece of ear, Aurore B. was "produced" by somatic cloning and was born by caesarean section on 24 January 2002 at the Bressonvilliers experimental farm. Aurore B. was a clone of her mother, Aurore, and her twin at the same time — cloning sparking blurred kinship. This birth came at a cost. Between January 2001 and July 2001, scientists carried out seventy-two embryo transfers, using oocytes from ovaries recovered on cows in slaughterhouses, and used only slightly fewer recipients in order to "obtain" Aurore B. Later in life, Aurore B. had four calvings (sired by Melchior, her father, the last of the herd whose semen was collected) of which three calves survived: Augure, Aurifère and Bazougers. But just like her, they were unable to leave the confines of the experimental farm.

Aurore B. was admired for her beauty, the color of her coat, her horns. She was what some would call a diva – a little jealous, cheeky and cuddly. She was stubborn, greedy, and very clever – "one time, she used her horns to unlock the fence by herself!" a geneticist told me. He wrote:

> ["Hi Roxane, thanks for your email and sorry I didn't reply to the previous one. To answer quickly, I've always been passionate about breeds in conservation and when I met Aurore B.'s gaze during trials I was doing at the experimental farm, I fell in love with her. There was really something special about her. I may not be objective, but I think that even people who hadn't heard of her story would have found her particularly charming."]

The diva was a star amongst scientists – a star still present in their stories today. Aurore B. died at the age of thirteen in December 2015 – the local newspaper covered her death as being "the story of a disappearance", interviewing animal technicians who were caring for her, saddened by the relative invisibility of the event. Yet, this was not the end of the story. A few years before, the charmed geneticist had been contacted by a couple of two farmers in Mayenne. They were breeders of Maine Anjou, a suckler breed very present in Western France, and they came with a problem: for quite some time, many of their calves had been dying very young, without them understanding why – and they had "really strange faces". It's difficult, because in addition to the financial losses, "you quickly lose a hard-won reputation", and they felt powerless. The geneticist, who also has a passion for horns, was in charge of the genetic anomalies' observatory, where he met them. They talked and decided to test an incriminated bull and several cows that had given birth to these strange calves. After investigating, he found the hitherto

Aurore B., the clone of Aurore, last representative of the Bleue de Bazougers breed.
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unknown anomaly on one of the bull's chromosomes. But the farmer was close to retirement, discouraged by these affairs, and having some issues with insurance companies. The geneticist then asked them if they remembered the Bleues de Bazougers, since they lived so close to their past home? Oh yes, they met them when they were kids… but that was a long time ago! Their parents, on the other hand, and many elders, remember them better. The geneticist told them that there were still frozen straws from two bulls, Melchior and Valeureux, and told him about the life and death of Aurore B. And so, the geneticist and these farmers came up with a crazy idea: why not reconstitute the Bleues de Bazougers?

Since 2012, in alliance with a dozen other farmers, they have been keeping the project of restoring this hardy, local breed of cattle alive — little by little, there are now around forty Bleues de Bazougers. But which breeds to choose to breed the Bleues? It has also been an investigative work on their part. To avoid inbreeding, a whole process is put in place which, partially through crossbreeding, creates inevitable hybridity. They tried to reconstruct the Bleues de Bazougers family tree (who were their ancestors? Who are their closest cousins?) to determine the best (or least bad) potential mating partners. When they heard of farms where there used to be cows with Bleues origins, they visited, discussed, and would do some tests. In the newly created breed association, we find the farmers themselves, the geneticist, but also some "old hands" — elders from surrounding villages, those who knew the Bleues, who can help determine the breed criteria. Because there's a particular issue around the blue coat (one of the Bleues de Bazougers' glorious specificities) is not genetically fixed, unlike the red or black dress. This white hair crisscrossing their back remains a bit of a mystery. While attempting to resolve these questions, the first cow of the line of reconstituted Bleues de Bazougers was born: a daughter of Melchior and a cow from the breed Rouge des Prés. They named her Jouvence, an auspicious name, calling for rejuvenation.

In 2018, the Bleues de Bazougers received a breed code, code 22: it took a lot of legwork, even a political battle, to get it and to finally gain the official recognition they had been denied for so long. So much for their revenge on Quittet! This recognition entitles them to subsidies, and they started already collecting semen from certain bulls to be sent to insemination centers. Still, Bleues remain complicated to classify. With the necessary crossbreeding, challenges arise. For example, under the Common Agricultural Policy, farmers receive fewer subsidies for Bleues because they are not considered to be a suckler breed… but they are not a dairy breed either… and there's no longer a "mixed breed" category! Do administrations prefer pure lineages? But the farmers, most of them working in grassland systems with extensive grazing, present the Bleues de Bazougers as a local heritage, as being particularly adapted to this area, to their specific environment and its variations. They are sturdy, good walkers, and able to make the most of coarse fodder, revelling in chestnut trees' leaves. And this, they add, is crucial to be well placed to get through the "hazards" of climate change.

Picture taken by the author, agricultural fair in Mayenne, July 2023

A fable for tomorrow: "The Cow Who Sang a Song Into the Future" Part 3

Seventy-six generations of cattle later, fields and meadows have become scarce under the grip of concrete, and ruminants have become itinerant. Their droppings are worth more than gold, seeding impoverished and contaminated soils, and their grazing regenerates burnt grass residues. They travel for kilometers, greeted by songs and caressed everywhere they go. When night comes and the thermostat finally drops below 33 degrees, we sit in a circle, surrounded by the smell of skin, sweat, and curdled milk, and we tell the story of the impromptu lives and interrupted lineage of the Bleues de Bazougers who escaped their planned disappearance. More hardy than their hyper-specialised cousins, they had been chosen as a breed "adapted" to climate change – the name given at the time to this period of multispecies hubris. The humid heat had hit much faster than anyone had imagined, and it was Jouvence who had been chosen for a genome-editing experiment, her body welcoming foreign alleles that gave her greater resistance to heat stress. These "carnal suggestions", formerly known as "GMO" or "NGT", were not immediately captured by big companies that would have put them at the service of a deleterious agro-industry as tools for the dispossession of land and knowledge. Deemed unmarketable because of European legislation in force at the time, the Bleues prospered at their own bovine pace, even redrawing the measure of human temporalities. Embracing their taste for the strange, the mutant character that makes up every animate being was now celebrated. After almost disappearing, they ended up outliving the other cows, and taught humans to live in the heat. Steady your heart rate, eat unhurriedly, salivate a lot, move slowly, and learn to ruminate with a soft, yet unceasing, attention.

Through this inquiry, my wish is to cultivate the connections and contrasts between the plural versions of the "cow of the future"; the genotyped, standardized, high-tech Holstein that is the center of attention in the laboratory, and the unexpected heirs of Aurore B., the reconstituted Bleues de Bazougers. These versions do not stand in opposition, both claim to be more "green" and adapted to a changing climate. What do we gain by cutting them off from each other? By showing their continuities and their differences, including in the territories they inhabit, condition, and transform, I wonder what hybrid alliances between geneticists and farmers are still possible.

In the story of Aurore, her clone Aurore B., and her impure (crossbred) daughter Jouvence (and the many others who followed), the worlds of the laboratory and the farm are constantly coming together. We witness a collaboration between geneticists and farmers, where reproductive technologies such as cloning and artificial insemination connect these worlds, and can support different realities. In the fable, I go as far as to imagine how "new genomic techniques" (NGT) such as gene-editing, could find other applications than keeping up with "business-as-usual", instead of drawing absolutely impervious boundaries between agro-industrial cattle farming and small-scale peasant farmers with a few cows on a hill. Differences matter, as such models do not produce the same worlds, but so do continuities, observing factually the already existing enmeshments of technologies, cows and humans. To escort us in this in-between zone, we could hint at Dolly, the first cloned sheep. As sociologist Sarah Franklin writes, "the most important questions posed to us by Dolly technology are less about where we are going than what we already are."[15]

Inquiring with one foot in the lab and one (booted) foot in farms, I seek to reorient the "cow of the future" within the web of clues and past histories that made these technologies possible. The ideal projections of this virtual being are already entangled in the present in games of practice. We are at a crossroads of temporalities, spectral presences, worlds that haunt us, and make us heirs of the cow of the future. Walking in the footsteps of the cow of the future is an inquiry based on traces of what has already happened, in an attempt to qualify what is yet to come. And to learn to listen to the "Cow Who Sang a Song Into the Future".

1 The title of this fable is borrowed from the film by Chilean director Francesca Alegria, "The Cow Who Sang a Song Into the Future", in which a herd of cows comes to haunt a young woman who was thought to be dead and who returns to the family farm. We too are inhabited by insisting presences. See: Francesca Alegria, *The Cow Who Sang a Song Into the Future* (Bord Cadre Films, Sovereign Films, Wood Producciones, 2022).

2 Rachel Carson, *Silent Spring* (Boston: Houghton Mifflin Harcourt, 1962).

3 David Lapoujade, Les *Existences Moindres* (Paris: Les Editions de Minuit, 2017), 13.

4 Ibid., 32.

5 Michelle Murphy, "What Can't a Body Do?", *Catalyst: Feminism, Theory, Technoscience 3*, no. 1 (2017): 1–15.

6 Edmond Quittet, *Les Races Bovines Françaises* (Paris: Centre National d'Information Économique, 1943), 9.

7 Julie Labatut and Germain Tesnière, «La race bovine Holstein, institution de la modernisation de l'agri culture entre bien marchand et bien commun,» *in Transformations agricoles et agroalimentaires: entre écologie et capitalisme*, ed. Gilles Allaire and Benoît Daviron (Paris: Quae, 2017).

8 Margot Lyautey and Christophe Bonneuil, «Les origines allemandes et vichystes de la modernisation agricole française d'après 1945,» *Revue d'histoire moderne & contemporaine* 69, no. 2 (2022): 86–113.

9 René Dumont, «La Structure Optima de l'agriculture Française Motorisée,» *Revue de l'économie Contemporaine*, no. 20 (1943): 22, quoted in Lyautey and Bonneuil, «Les origines allemandes et vichystes,» 100.

10 Inès Léraud and Pierre Van Hove, *Champs de Bataille. L'Histoire Enfouie Du Remembrement* (Paris: Delcourt et la Revue dessinée, 2024).

11 Léo Magnin, *La Vie Sociale des Haies* (Paris: La Découverte, 2024).

12 Daniel Delahaye, Mathilde Guillemois, and Thibaut Preux, «Les trajectoires d'évolution des réseaux de haies : du diagnostic territorial aux outils de simulation» (Réseau Haies France, 2023), 5.

13 Les Soulèvements de la Terre, *Premières Secousses* (Paris: La Fabrique, 2024).

14 Donna Haraway, *Staying with the Trouble: Making Kin in the Chthulucene* (Durham: Duke University Press, 2016).

15 Sarah Franklin, *Dolly Mixtures: The Remaking of Genealogy* (Durham: Duke University Press, 2007), 17.

This picture was taken by Alain Coulon, one of the farmers who collaborated with the geneticist for the reconstitution of Bleues de Bazougers. He appears on this picture, placed in his living room, along with his cows.

THE GEN(I)ES IN THE COLONIAL ARCHIVE.

TELLING THE STORY OF CATTLE FARMING, SELECTION, AND REPRODUCTION THROUGH ZOOTECHNICAL RECORDS: THE CASE OF FASCIST ITALY 1910-1940

DANIELE VALISENA

“To the Duce, we can clearly say that Italian colonial scholars are a militia ready to operate in the field of science to increase the glory and the greatness of the nation”[1]. Those were the concluding remarks of the Second Congress of Italian Colonial Studies, held in Naples on October 5th, 1934. Exactly one year later, the Italian Fascist Army would be setting Ethiopia on fire in the beginning of one of the last and bloodiest colonial conquest wars of the twentieth century. As is often the case in colonial projects, Italian “scientific militia” had been paving the way for the Fascist Army.

As the pioneering works of Harriet Ritvo and Aflred Crosby have shown in the case of British colonial history, imperial rule went hand in hand with organizing, categorizing, and ultimately exploiting animals and the natural world; a process that, in turn, also shaped English identity[2]. Similarly, other European imperial powers worked to organize, transform, move, and reproduce nature to advance both national and colonial agendas. Italy, as a latecomer to both national unification and imperialism, presents a particularly intriguing case, especially given that much of its scientific modernization took place under fascist rule. This article examines the discourses, practices, and techno-natural policies of fascist animal husbandry in early twentieth-century Italy.

While taxonomy sought to classify all living beings into hierarchical and progressive categories, influencing animal reproduction was a costly and labor-intensive endeavor, often dependent on vernacular knowledge. In the early twentieth century, genetics appeared to offer a “Rosetta Stone” for understanding and controlling animal reproduction and selection. More recently, the advent of genomics has promised to unlock the secrets of animal biology through bioinformatics and supercomputing. However, before these advanced technologies existed, animal husbandry was a more rudimentary science—one that served national, social, and political objectives as much as it intersected with other scientific fields and ideologies. Journals, reviews, and official records from the era reflect these early efforts to modernize both human and non-human populations in service of broader political, racial, cultural, and scientific agendas.

This article explores the impact of genetics on animal husbandry practices and theory in Europe, with a focus on Italy, a peripheral region of modern Europe at the time. By investigating how animal husbandry was mobilized first by the newly unified Italian Kingdom and later by the Fascist imperial regime, I analyze how animals and their bodies were classified, modified, and selected by scientists, farmers, politicians, and broader social groups. The tentative—and often self-serving—application and misapplication of genetic theory underscores that science never occurs in a vacuum.

In a time when new forms of settler-colonialism still use the same modernist and white-supremacist rhetoric to justify xenophobic and genocidal politics in Palestine, it is more important than ever to clearly retrace the political, scientific, and racist legacy from where those discourses and practices originate.

A POLITICAL ECOLOGY OF CATTLE GENEALOGY IN 1910S ITALY

In 1912, Carlo Pucci published the first national atlas of Italian bovine breeds[3]. The volume was meant to provide the first comprehensive overview of the Italian cattle population, and it had three intentions. First, the atlas was meant to illustrate the variety and specificities of Italian farm animals and to make order in what was at the time mostly non-scientific panorama of Italian breeds. Secondly, the volume intended to be a sort of guide to Italian farmers in their slow progress towards the modernization of the national animal farming industry, which was underdeveloped compared to other European nations like Germany, France, and the United Kingdom. Finally, the book sought to bolster Italy's national and imperial identity. In 1912, Italy had recently invaded and conquered Libya and was ambitiously pursuing further colonial expansion in East Africa. At the same time, Italy was preparing to claim its *terre irredente* (unredeemed lands) in the Northeast. Within this context, asserting ownership over Italian natures—whether in the form of territories or farm animal populations—became a potent political tool that scientific endeavors helped legitimize. The atlas supported this agenda by offering a taxonomic, geographical, and economic classification of all bovines inhabiting Italy's metropolitan and colonial territories, as well as the contested *terre irredente*, and the newly acquired colonial territories in Africa.

Animal breed atlases were common during this period, forming part of the broader world-ordering project that European scientists had pursued since the advent of colonial enterprises in the fifteenth century. Much like cartography, the scientific study of the natural world was inextricably linked to its political organization through colonialism and its socio-economic subjugation via capitalism.[4] The continuous appropriation of resources, alongside the devaluation of life and cultural products outside of the white-European framework, was integral to the imperial project of domination.

The Encyclopédie represented a bold expression of European modernization ideology's universalist ambitions, while Linnaean taxonomy served as its counterpart in the natural sciences.[5] This taxonomic approach was later advanced by various scholars and practitioners with a specific focus on farm animal breeds. Interestingly, while the precision of the English language distinguishes between "human races" and "animal breeds", many Roman languages (including Italian as well as Dutch and Danish) lack such linguistic subtlety, using a single term: *race, razza, raça, ras, or rasse*.[6] This linguistic overlap underscores the inherently political nature of discussions about animal breeds, which are invariably tied to discourses on human races, natural hierarchies, and their place within the world.

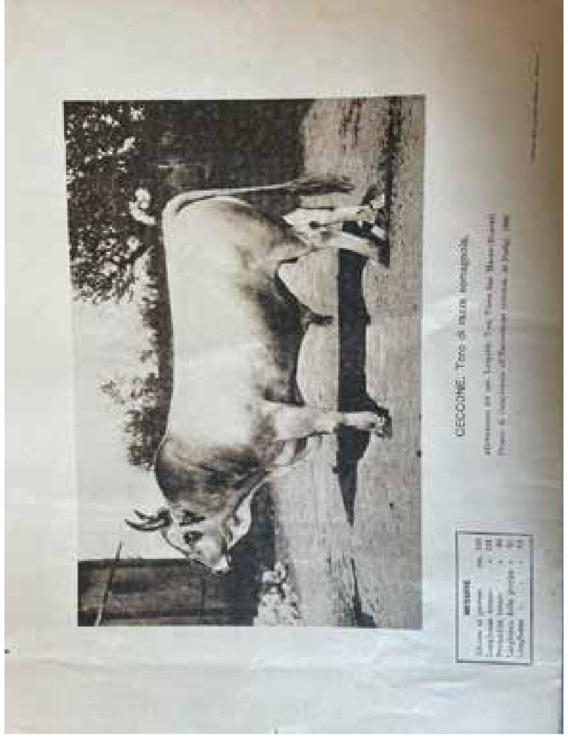
Building genealogies in the Linnaean tradition was far more than a scientific endeavor; it was a political and ecological act of ordering—a biopolitical gesture. Defining an animal's characteristics was simultaneously a decision about its economic and social value, as well as its position within a species hierarchy, a hierarchy that inevitably placed white, wealthy European males at the apex. It is, therefore, no coincidence that the largest empires of the nineteenth century—first the French and later the British—were the most active participants in this scientific "'race" to define the world and assign its inhabitants their places within it.

SELECTION, IMPERIALISM, AND THE CLASH OF CIVILIZATIONS

In the section on anthropogeography of his geography and geology handbook for secondary schools —first published in 1941 and in use in Italy until 1960s — Manfredo Vanni wrote that:

> The development of civilization and means of communication, and the expansion of trade all contribute to complicating the distribution of races […] However, the force of civilization and expansion of certain races tends to destroy inferior minor races which, little by little, disappear.[7]

According to the Italian geographer, as more advanced civilizations subjugated and, progressively, absorbed or eliminated supposedly inferior populations, they inscribed both their cultural and genetic stock on the territory they conquered (he presents the cases of North America and Australia), but also their companion animal stock. This pro-colonizing and pro-European imperialist vision conceives of history as a process of natural selection that involved humans and non-humans, and which was based on the capacity of certain populations (or "civilizations", in the imperial language of the author) to develop and improve nature. To this respect, it is worth noticing how this concept was employed in relation to colonization and emigration, two key aspects of Italian politics during the Fascist Era. In the fascist colonial narrative Italians were considered an elect race as per their history and anthropogeographical “force of civilization”, so Italian natures were “naturally” superior to colonized natures too.



Ceccone, Romagnola Bull. In Atlante monografico delle principali razze bovine italiane

Italy, as a latecomer in the imperial race, struggled to position itself among the established European colonial powers. At the same time, it sought to craft a unifying national narrative capable of consolidating the fragmented patchwork of small states and free cities that had been unified into a kingdom between 1860 and 1870. Italy’s animal populations mirrored this political, social, and cultural fragmentation, while the backwardness of Italian agriculture underscored the dire economic and social conditions prevalent in much of the countryside. Alongside the economic and social discourse surrounding Italy’s delayed modernization, the bio-political hierarchy of European populations provided scientific validation for Italy’s perceived inferiority, manifesting in claims of the degenerated racial status of Italians.

Although Italy’s Roman past, Christian religious primacy, and the myth of the Renaissance positioned ‘the boot’ as a foundational pillar of white Europeanness, its economic hardship and geographic and racial proximity to Africa and the Middle East threatened this identity. This question of Italian whiteness was not merely an academic debate or prejudice faced by Italian immigrants in the Americas.[8] Rather, it was a matter of national concern. As migration scholars have shown, scientific racism and social Darwinism shaped state policies, providing scientific legitimacy to inequalities across political, social, economic, cultural, racial, and gender lines.[9] To be demoted in the supposedly scientific racial hierarchy of world races effectively naturalized a state of inferiority.

The first systematic efforts to study differences within Italy’s populations came from Italian anthropologists such as Cesare Lombroso, Alfredo Niceforo, and Giuseppe Sergi. The so-called Turin School of Criminal Anthropology, founded by Lombroso, sought to investigate the supposed inferiority of Southern Italians, who were constructed as the “negative other” in contrast to the “modern Northern Italian man”.[10] This narrative was bolstered by social Darwinism, scientific racism, and pseudo-scientific methodologies such as phrenology, which were used to justify Northern Italians’ alleged superiority and alignment with white European modernity. Conversely, these same discourses reinforced the characterization of Southern Italians as economically, socially, and culturally backward.

The encounter with the Southern Italian “other” legitimized Northern Italian superiority, while encounters with the non-white “other” allowed Italians to reaffirm their whiteness and assert a supposed higher degree of biological and socio-cultural modernity. Although this is not the place to fully examine the history of scientific racism in relation to European hegemony, it is crucial to note that these discourses were deeply intertwined with studies of animals and nature that captivated the young Italian kingdom and Europe at large.

It is within this context that publications such as the *atlas* must be understood. Geographical determinism, highly regarded at the time, posited a direct relationship between a population’s characteristics and the environment in which they lived. According to geographical determinism, discrete environments produced different human societies with specific cultures, biological traits, cognitive capacities, and social behaviors. Farm animals, as extensions of this political ecology, were seen as expressions of their environments and the societies that produced them, thus their traits could be used to justify white European dominance.

RAZZA ROMAGNOLA: THE POWER OF GENEALOGY

One emblem of modernization in early 20th-century Italian cattle farming was the *razza Romagnola*. Part of the podolic white cattle family that ranged along Italy’s Adriatic coast from Veneto to Apulia, this breed, native to the provinces of Ravenna and Forlì, was undergoing a successful process of improvement. Its quality was validated when select specimens received awards at the 1900 World Fair in Paris.[11] The Romagnola breed had gained popularity due to its suitability for meat production, which animal husbandry scholars and practitioners deemed central to modernizing Italian agriculture.

The low meat consumption among most Italians was considered both a symptom and a cause of their physical frailty, short stature, and, possibly, their perceived lack of fighting spirit.[12] These alleged deficiencies were starkly highlighted by Italy’s disastrous attempt to conquer Ethiopia, culminating in the 1896 defeat at Adwa against the *negus*’s army—the first significant loss by a European state to an African nation. The defeat forced Italy to halt its colonial ambitions for 15 years and led to the resignation of Prime Minister Crispi.

While contemporary science recognizes that meat is not strictly necessary for a healthy diet — its protein content being replaceable with legumes, fish, and vegetables — the vast majority of early 20th-century scholars believed meat consumption was crucial for building strong, masculine, "imperial" bodies. The traditional Italian countryside diet was notably low in meat due partly to cultural habits and partly to economic constraints. Many families could not afford meat even on a weekly basis, and Italians consumed far fewer dairy products and eggs compared to their European counterparts. Italian agriculture appeared structurally incapable of producing the quantities of animal products required to sustain a national dietary shift. According to Vittorino Vezzani, vice-president of the Corporation of Zootechnics and Fishing, the average Italian consumed just 18 kg of meat per year in 1925, a figure that dropped to 14.57 kg by 1930. For comparison, Belgians consumed an average of 38.7 kg, the English 59.7 kg, Americans 68 kg, and Argentinians a staggering 115 kg per year.[13] In response to this crisis, the Italian government launched the "Battle of Zootechnics" in 1931, a major national campaign aimed at increasing meat and dairy production.[14] The successful improvement through selection and cross-breeding of the Romagnola breed could be the leading example to change this grim state of things and allow Italians to fully acquire white imperial bodies like their counterparts on the other side of the Alps. This was the contribution that Italian animal husbandry offered to the imperial dreams of the Fascist Government.

Another notable characteristic of the Romagnola breed was its genealogy. In an era when animal husbandry was still emerging as a defined science, the perceived key to the future of animal selection lay in the past. While evolutionary theory and genetics were beginning to influence agricultural policies in other European countries, many Italian zootechnicians adhered to the ideas of Auguste Sanson. The French professor argued that all animal species were created at their full potential in a distant past, and that present-day specimens represented degenerated versions of these original pure breeds. According to this view, the goal of animal selection was to recover the original characteristics of each species or breed.[15]

Although Sanson's theories faced criticism from scholars in France and across Europe, they retained significant influence in Italian zootechnical schools[16]. These ideas aligned with broader nationalistic narratives, which cast Romans as the noble ancestors of modern Italians and Europeans at large. Scientific and racial genealogies paralleled these political discourses, valuing ancient and supposedly less-degenerated animals as the purest and most valuable. The guiding principle of this selection process was *atavism*—an attempt to recover dormant traits of ancestral animals. While atavism can occur naturally and it is not inherently good nor bad per se,[17] around the end of the nineteenth century, the concept became known to the general public following the criminal atavism theory of Cesare Lombroso. According to the Italian anthropologist, atavism was a form of degeneration, the reappearance of past physical and behavioral traits belonging to less evolved ancestors.[18] This is how the concept has been understood by eugenics and, conversely, also genetics for many years.[19] However, in a context where political, cultural, and scientific discourses were intertwined with ideology, the pursuit of mythical ancestry became a key component of animal husbandry policy in Italy.

Following this approach, related breeds of white podolica cattle, such as the Maremmana, gained recognition for their versatility in meat production and labor. The Maremmanas—connected to the Ukrainian cattle—were introduced to Italy by the Lombards, and their status as one of the oldest breeds in the country encouraged zootechnicians to continue inter-breeding selection processes championed by the Romagnola. These cattle were not only becoming more productive in meat yield but were also increasingly viewed as "purely Italian" by animal husbandry scholars due to their classical ancestry.

Debates over the definitions of race and breed became a contested terrain for both scientists and practitioners. Balancing personal convictions, experiential knowledge, scientific evidence, and national ideology was a complex task. While countries like the USA and Japan, alongside other European nations, engaged in similar discussions, the rise of fascism in Italy during the 1920s and 1930s brought new dimensions to these debates. Examining fascist politics of nature through the lens of animal husbandry highlights the deep political and ideological underpinnings of agricultural and farming policies, particularly in relation to colonial ambitions.

THE LIBYAN CATTLE: PRACTICE VS IDEOLOGY

While Italy failed to conquer Ethiopia in 1896, it maintained colonial outposts in East Africa, specifically Eritrea and parts of Somalia. The military victory of 1912 expanded these holdings to include Libya's coastline. In East Africa, cattle primarily belonged to breeds derived from *Bos Indicus* (zebus), though some had interbred with *Bos Taurus* breeds, the family to which European cattle belong. The ephemeral nature of Italian settlements—centered mostly around port cities—and the harsh climate delayed any large-scale agricultural or farming programs in East Africa until the 1930s. Libya, however, presented a different case.

Located just across the Mediterranean Sea, Libya became Italy's primary colony during the Fascist Era, often referred to as the *Fourth Shore of Italy*. Its proximity, along with its mixed population of Arabic-speaking communities, Jewish traders, and Mediterranean "white types," created a blurred racial frontier. This ambiguity extended to its natural environment, as Libya was unique among African territories for having cattle breeds derived from *Bos Taurus*.

By the early 1930s, Fascist Italy had subdued Libyan resistance and secured most of its territory. Alongside the military campaigns and the displacement of indigenous populations into desert concentration camps, the Ministry for Colonies initiated plans for settlements in the newly conquered lands. These settlements were designed to host independent and self-sustaining farming communities selected by a Colonization Institute with regional branches across Italy. The arrival of "the 20,000" Italian colonists in 1938 represented the most propaganda-heavy colonial scheme of the fascist government. These settlements aimed to Italianize and modernize Libya. By introducing white Italian settlers and recreating a Roman Mediterranean landscape, the Fascist regime sought to transform Libya into a productive extension of Italy. This transformation relied on the forced eradication of indigenous people and local ecologies, including native cattle. The Italianization of Libya mirrored the ambiguous objectives of Italian animal husbandry: reconstructing a mythical and modernized Roman environment to assert Italian control and productivity over a land perceived as "non-modern." To achieve this, fascist policies mobilized not only Italian labor and technology but also Italian "natures," which included cattle.[20]

As promoted by the Fascist propaganda office, Italian cattle were brought to Libya to support local farmers with agricultural work and to provide meat for Italian colonizers. The selection of Maremmana oxen by the Libyan Colonization Institute was no coincidence. The Maremmana breed, living in the reclaimed Maremma swamps in central Italy, was closely tied to fascist land reclamation efforts on the Peninsula, particularly through the widely publicized *bonifica integrale* program of land reclamation and state-assisted migration.

Maremmana cattle were considered among the most ancient and hardy of all Italian breeds, making them ideal candidates for Libya's colonial land reclamation project. This effort aimed to construct a modern Italian future in Libya by restoring what fascists imagined as the ancient Roman environment—an ecosystem they claimed had been disrupted by centuries of Arab and Ottoman rule. Just as Italian animal husbandry sought to recover "original" pure breeds of livestock, fascist colonizers aspired to recreate the "pure" Italian landscape. The plan involved transporting Italian farmers and their families, establishing new Italian villages, planting olive trees and wheat, and introducing Italian cattle. These measures were designed to solidify Libya as an italianized and productive extension of the motherland.

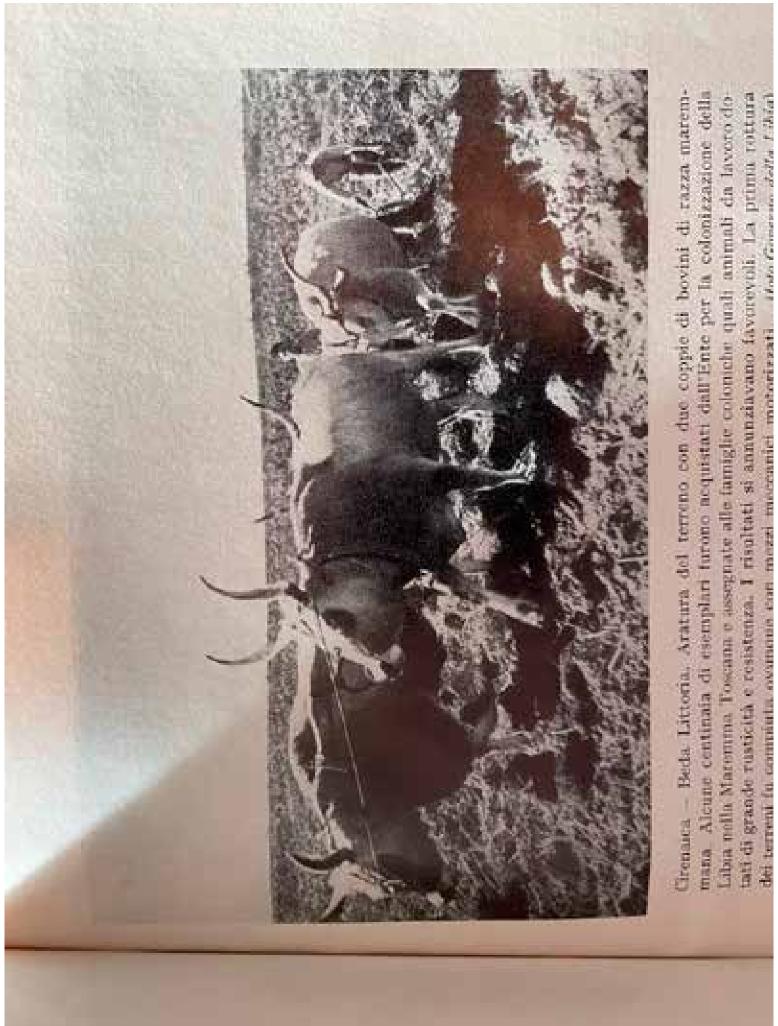
Gharian Bullock from Libya, 15 month.
In Atlante monografico delle principali razze bovine italiane

However, the reality on the ground was far less ideal than the promises of propaganda and ideology. Libya's scarce water resources, inadequate irrigation infrastructure, extreme heat, and poor-quality fodder took a devastating toll on the Maremmana cattle population. The situation became dire during the 1936 drought, which severely impacted Italian colonial settlements. In response, an assisted transhumance was organized, involving the transport of over 300,000 cattle and sheep from western Libya to the eastern province of Cyrenaica. This operation was executed using Italian private ships, required 50 trips, and cost 1,600,000 lire, more than the total sum of Italian import and export to Italian East Africa in the same year.[21] The immense expense and logistical challenges of this operation far exceeded the self-sufficiency goals of fascist autarky. Ultimately, the dream of transforming Libya into the Fourth Shore of Italy collapsed under the weight of ecological impracticality and the ideological hubris of fascist and zootechnical policies.

CONCLUSION

While the story presented in this essay does not fully encompass the complexity of colonialism, fascism, and animal husbandry, it highlights how politics and ecology intersect, demonstrating how animal bodies became a battleground where the desired futures of Italy, Italians, and the Fascist Empire were contested. Genealogy, a concrete application of scientific animal selection and breeding, emerged as a political tool—an instrument capable of steering national farm animal breeding policies and justifying Italy's place among modern nations. The principle of ancient purity, inspired politically by a fascination with Roman greatness and the Renaissance's discourse of modernity, was reinforced by creationist pseudo-scientific theories such as those supported by the followers of French zootechnician André Sanson. Translated into the Italian context, the construction of a specific notion of Italianness and Italian modernity served as a means to justify the socio-economic and political dominance of Northern Italy over the South. This inward process of identity construction and othering paralleled the way social Darwinism and criminal anthropology served as theoretical frameworks that informed Italian colonial policies and reinforced Italian whiteness and modernity at the expense of colonial subjects. This process can be traced through the role played by Maremmana and Romagnola cattle breeds in shaping national and colonial policies before and during the Fascist Era.

While there were voices opposing the decision to import Italian cattle into the colonies, political ideology during the final years of the Fascist regime was so powerful that it shaped and manipulated scientific perspectives to suit its agenda.[22] What I have aimed to show is that, alongside political ideology, a form of scientific ideology also existed—one that convinced Italian colonizers they could remediate and completely reshape the socio-environmental infrastructure of Libya, just as they had done with land reclamation projects in Italy. Ultimately, the Battle of Zootechnics failed both in Italy and in the colonies, illustrating how ideology can intrude upon science and politics in profoundly detrimental ways.



Beda Littoria (Libya). Sowing with two Maremmana oxen. In L'Africa Italiana. Bollettino delle Società Africana d'Italia, 53, n. 1-2, 1934

1 Piero Ginori Conti, "Conclusions to the Second Congress of Colonial Studies", Naples, 1-5 October 1934, in *L'Africa Italiana*, 3-4, (Settembre-Dicembre 1934), translation from Italian by the author.

2 Harriet Ritvo, *The Platypus and the Mermaid and Other Figments of the Classifying Imagination*, (Cambridge, MA: Harvard University Press, 1997); Alfred Crosby, *Ecological Imperialism The Biological Expansion of Europe, 900–1900*, (Cambridge-New York: Cambridge University Press, 2004).

3 Carlo Pucci, *Atlante monografico delle principali razze bovine italiane* (Florence: Istituto Micrografico Italiano, 1912).

4 See Franco Farinelli, *L'invenzione della terra* (Palermo, Sellerio, 2007).

5 See the "Introduction" in Dipesh Chakrabarty, *Provincializing Europe. Postcolonial Thought and Historical Difference* (, Princeton NJ: Princeton University Press,2007); Walter Mignolo, *The Darker Side of Western Modernity Global Futures*, *Decolonial Options* (Durham NC: Duke University Press, 2011).

6 I wish to thank Jenske Bal for making me aware of the Dutch and Danish words.

7 Manfredo Vanni, *Corso di geografia generale e geologia per la scuole medie superiori* (Milan: Carlo Signorelli Editore, 1940), p. 256-257.

8 On the debate on Italian whiteness in the USA, see Jennifer Guglielmo, *White on Arrival: Italians, Race, Color, and Power in Chicago, 1890–1945*, (Oxford-New York: Oxford University Press, 2003).

9 See Katherine Benton-Cohen, *Inventing the Immigration Problem. The Dillingham Commission and Its Legacy* (Cambridge MA: Harvard UP, 2018); Adam Rutherford, *Control: The Dark History and Troubling Present of Eugenics* (New York: W.W. Norton, 2022).

10 See Carmine Conelli, *Il rovescio della nazione. La costruzione coloniale dell'idea di Mezzogiorno* (Naples: Tamu Edizioni, 2022), pp. 61-103.

11 Vincenzo De Carolis, L'allevamento dei bovini (Opera Nazionale Combattenti, Rome: 1927).
See Dino Sbrozzi, La razza bovina Romagnola dell'azienda Torre San Mauro (Fattoria Torlonia): Esposizione di Parigi, anno 1900, (Rimini: Tipografia Capelli successore Malvolti, 1900).

12 See Daniele Valisena, "Fascisme et zootechnie", in Pierre Serna, Véronique Le Ru, Malik Mellah, and Benedetta Piazzesi (eds.), Dictionnaire historique et critique des animaux (Paris: Champ Vallon, 2024), pp. 290-294.

13 Vittorino Vezzani, *Crisi zootecnica e nuove direttive per il miglioramento: discorso pronunciato alla Camera dei Deputati nella tornata del 18 febbraio 1932* (Roma: Tipografia della Camera dei Deputati, 1932).

14 See Daniele Valisena, "The Battle of Zootechnics. Incorporating Race, Technology, and Ideology in Cattle Breeding Practices during Fascism in Italy (1922-1945)", *Isis. A Journal of the History of Science Society* 116 (3), 2025.

15 See André Sanson, *Traité de zootechnie Vol. I* (Paris: Librairie agricole de la Maison rustique, 1893).

16 Vincenzo De Carolis, *L'allevamento dei bovini* (Opera Nazionale Combattenti, Rome: 1927).

17 For instance, now geneticists draw upon this reasoning to produce more sustainable and climate
18 change-resilient farm animals. See Jenske Bal and Roxane Gabet in this volume.
Cesare Lombroso, *Criminal Man* (Durham NC: Duke University Press, 2006; 1876).
See Mark Lubinsky, "Degenerate Heredity: The History of a Doctrine in Medicine and Biology", in *Perspective in Biology and Medicine* 37 (1), 1993: pp. 74-90; Philippa Levine, "Anthropology,
19 Colonialism, and Eugenics", in Alison Brashford & Philippa Levine (eds.), *The Oxford Handbook of the History of Eugenics* (New York: Oxford University Press, 2010), pp. 43-57.
Roberta Biasillo, "Socio-ecological colonial transfers : trajectories of the fascist agricultural enterprise
20 in Libya (1922–43)", in Roberta Biasillo, Daniele Valisena, Claudio De Majo (eds.), Environments of Italiannes. Special Issue on Modern Italy 26 (2), 2021, pp. 181-198.
21 See Gian Luca Podestà, *Il mito dell'impero. Economia, politica e lavoro nelle colonie italiane dell'Africa orientale 1898-1941* (Torino: Giappichelli, 2004), p. 258.
For instance, Manlio Bettini, *La Zootecnia nel Sud Africa* (Florence: Istituto agricolo coloniale italiano, 1938).

ON SEQUENCES AND SPACES IN BETWEEN

FRANÇOIS THOREAU

A genome is a sequence of genes. A full sequence supposedly encompasses all the genes contained in a biological entity — an organism. Other forms of sequencing may include some parts of all the genes, or some genes of specific parts. The problem rests with "the how". How are genes organized? How are they ordered? How is the totality of an organism pursued or sequenced? Those questions are too big to grasp here, but engage with the ways and means of classification, the very act of making lists and grouping stuff[1].

Let us start from a curious regulatory artefact: an official regulation adopted in 2014 by the Swiss Federal Food Safety and Veterinary Office (FSVO)[2]. The items in the following list have a strange poetry to them, coexisting as they do alongside a regulatory ban on the farming of purebred Belgian Blue cattle.

> Article 10 Prohibited breeding varieties
> The following breeding varieties are prohibited:
> A. dancing mice;
> B. goldfish of the varieties 'bubble eye', 'stargazer' or 'telescope eye';
> C. dwarf dogs weighing less than 1,500 g in adulthood;
> D. cats with exceptionally short forelegs (kangaroo cats);
> E. reptiles with enigma syndrome;
> F. purebred Belgian Blue cattle.

Article 10 of this animal protection regulation contends that certain breeds of animals are subject to a formal ban on breeding. This ban applies as cited in the list to "dancing mice" and goldfish of the "Uranoscope", "Celestial Fish", and "Telescope Fish" varieties. It also includes "dwarf dogs", which weigh less than 1,500 grams when fully grown, or cats whose front legs are extremely short, so short they are referred to as "kangaroo cats". The list goes on to ban the farming of reptiles' specimens burdened with the Enigma syndrome. Finally, the restrictions on cattle include specimens of the purebred Belgian Blue breed.

This list combines the strange with the bureaucratic — a technical document that opens onto odd dimensions, drawing links between very different kinds of beings. Such lists establish a plan of coexistence, where very different entities are placed next to each other. These entities differ not only in kind, but also in their relationship with one another. For instance, some people cherish dwarf dogs as pets, while dancing mice have become objects of scientific curiosity and animal models for laboratory sciences. By contrast, Belgian Blue is the most common breed of cattle in Wallonia, Belgium. Therefore, this peculiar item of the regulation does not concern pets or animal models, but rather the everyday practices of livestock farming, an activity carried out for very different reasons than petting or scientific curiosity. Belgian Blues are selected primarily for the ratio of meat to carcass, rather than for their appeal as pets or for the curiosity surrounding their behaviour.

Something striking about this list is how heterogeneous the categories of entities on display are. There was some poetry in their denomination, but also a sense of incongruity stemming from their coexistence. I couldn't help but laugh in bewilderment, thinking about Michel Foucault's laughter at Jorge Luis Borges' list, in which the latter *"quotes a 'certain Chinese encyclopedia' in which it is written that 'animals are divided into: (a) belonging to the Emperor, (b) embalmed, (c) tame, (d) sucking pigs, (e) sirens, (f) fabulous, (g) stray dogs, (h) included in the present classification, (i) frenzied, (j) innumerable, (k) drawn with a very fine camel hair brush, (l) et cetera, (m) having just broken the water pitcher, (n) that from a long away off 'look like flies'"*[3].

There is a sense of oddity arising from such strange juxtapositions. It does not really matter if the different groups that order such a variety of beings do speak to each other. Something in this juxtaposition creates what Umberto Eco calls "the vertigo of the list"[4]. This vertigo stems from the spaces in-between such diverse entities. What is properly vertiginous, is that the lists, just as the regulatory article quoted above, enlists very different things from very different groups. If it was not for the fact of their being on the list in the first place, the act of grouping these things together reveals how distant they are from each other, and how little they are related. This makes the space of the list a strange space, fundamentally unbounded, fragmented and shattered, with no other cohesion than the bullet points that sit to the left of each item.

For example, in his book *The Infinity of Lists*, Eco reports attempts at telling Achilles' stories from the Iliad on "an impossible shield" allegedly forged by Hephaistos, a round and unified surface where all the stories could be depicted and contained. Historians and blacksmiths have tried, in vain, to figure out how such a shield would be made possible, and even tried to reproduce it. The list was overflowing that mere surface — and by quite a margin. The only way it could work was by distorting some of the events so that they would fit in the round frame of the shield, and by suggesting others events that would only begin after the surface of the shield ends and be continued elsewhere, out of its bounded world.

There is only so much diversity a bounded space can hold. At some point, a multitude of items can only be held to account by shattering the space in which it is allowed to exist. The diverse entities do not belong to one same world but to different worlds, and the feeling of oddity comes from the sense of endlessness, of indefinite possible prolongations of the list. In this context, what lies outside the frame, the *hors-champ*, may be more significant than what is inside. The list gestures toward proliferation, swarm, sprawl — it strives to suggest what always exceeds it: the infamous *"et caetera"* which refuses to mark an end to a list to the teeming margins and the populated peripheries of the untold. Perhaps the feeling of oddity stems from the way "reality" exceeds virtuality, not the other way around.

A genomic sequence is, at first approximation, the exact opposite of a classification. It is an operation as well, but one that seeks to record. A sequence is, by definition, both an "ordered series of elements or actions," and, in computational terms, a "succession of executable operations"[5]. It is an enumeration, or a series of things brought together in the shared and ordered space of the sequence. But the space of the sequence is quite different from the space from the list. What sort of space does the sequence open up?

The things it orders are nucleotides constitutive of DNA. The groups in which it orders things are scarce: A and T, G and C. Only four letters taken out of the Latin alphabet to represent the nucleotides bases, and yet enough letters to claim to write and rewrite "the book of life", as the famous metaphor goes[6]. The containers for ordering the world are quite slim in terms of significance, mere letters that do not say much and seem even. As the sequence goes on, it does not seem to matter much if a particular genetic variant is classified under A or T, G or C. All it says is that, as a nitrogenous molecule, its structure differs from the other bases. These differences, however, become reabsorbed into the length of genetic sequences. Provided there can be up to 6.4 billion bases in a cell, and around 30-40 trillion cells in a human body, the list here can get quite long, and the book of life, made from only four letters, quite boring and exhausting to read *in extenso*.

As containers within which to order entities, A, G, C or T do not tend to speak for themselves. What matters there is more to describe the nitrogen molecules that are part of a cell; it is more a matter of recognition of one of these four patterns, depending on the structure of the molecule. Only once this long and painstaking sequence is performed does it become possible to further classify, compare or apply a wealth of different uses. In that sense, the sequence itself claims to pertain to a sort of digital agnosticism: a long, indifferent series of entities rather silent about their *a priori* meaning, the coexistence of which cannot drive any sense of surprise, let alone, oddity; A, G, C or Ts, and eventually binaries like 0s and 1s in their digital rendering. The sense of vertigo stems not from the incongruity of putting A's side to side with G, C or T's, but rather from a longitudinal alignment that appears almost infinite. It is claimed that there are more bases of DNA in a human body than stars in the observable universe[7]. This is a stretch, in the most literal sense of stretching. This is not the rule of the odd but the rule of the even.

This elongation is where bewilderment begins—in a finite, yet daunting stretch of billions of base pairs. No wonder though, that this immensity must be reduced somehow to make it actionable. Everything then depends on how the so-called "raw data" is processed—how it is filtered, cleaned, reduced, and, again, paying attention to everything that it leaves out of the genetic scope. Data are never given simply, without mediation or limitation[8]. Every sequencing is made from decisions and trade-offs—about what to include, what to ignore, what to treat as noise, what to elevate as signal. In such cases, the contrast does not stem from heteroclite groups that relate to each other in odd manners. It rather takes the form of a quest for significant variations. But that is only the point of departure. Sequencing is like learning how to swim in a sea of DNA bases that pretty much look alike and only differ in their margins. In which area or which region is it likely to be found? Then what would it tell us? A lot of variants are not so clear about what they say exactly, the kind of difference they signal for an organism. Are they significant or not? I like it that so many of them are said to be "of unknown significance"[9]. And significant for what purpose? The purpose is likely to be health-related for human beings, but sequencing can have very different purposes like for example anticipating on the milk production of a cow's offspring. Sometimes, looking at a sequence delivers much more information than what was needed or even desired, and sometimes scientists or geneticists alike find themselves overwhelmed with bits of information they do not really know what to do with or how to handle.

That is telling of the sort of perimeters sequencing delineates, by contrast to the grouping performed in the Swiss regulation examined in the introduction of this text. The latter is shaped by the simple condition that all the entities pertaining to the list share a genetic defect. This underscores the rationale for drawing a space in which these odd groups may coexist. Sequencing techniques are diverse and bear different aims and scopes, yet it is tempting to see them as a shared quest or singular experimental approach to variations. It is closer to fishing than to ordering,

where sequencing provides the pond in which to fish. Sequencing disguises its scaffolding. It creates a space which is constantly expanding, becoming more and more difficult to grab a hold of[10]. In a way, the practice of sequencing reproduces a sort of infinity. Not a list-like infinity which rests in between the entities that are part of that list, in a sense of vertigo that stems from the incommensurability of these entities. Rather, it is a longitudinal infinity that counts billions of pair bases one after the other, delineating a close to infinite succession of a priori eventless and insignificant letters. Only then does it become possible to compare, locate, and attribute significance.

Thus, the image of the sequence as a long string of binary code becomes difficult to apprehend as anything other than an endless meme with scarce variations. What matters is not the resemblance, but the subtle divergences from one organism to another. The spaces in between bases of DNA are smaller and perhaps less bewildering than the gaps between items on a list, yet they can be in indefinite expansion. We also find a lot of oddity in these base-pair gaps which are not located or disposed in the same way as gaps on a list. For this reason, a sequence can take us quite far in expanding our understanding of the infrastructure of life. A sequence is less a representation than a gesture—a performance of possible variation which frames life through an illusory exhaustion of combinations which begin to seep through the gaps as soon as they are laid out. In short, this is where the poetry begins.

1 Geoffrey C. Bowker and Susan Leigh Star, *Sorting Things Out: Classification and Its Consequences* (MIT Press, 2000).
2 Ordinance of the FSVO on the protection of animals in breeding, 4 December 2014 (455.102.4).
3 Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (Vintage Books, 1994; originally published 1970).
4 Umberto Eco, *The Infinity of Lists* (Rizzoli, 2009). See also the hilarious and much vertiginous "list of lists of lists" entry on Wikipedia encyclopedia: https://en.wikipedia.org/wiki/List_of_lists_of_lists (consulted 2025-07-5).
5 This definition I found in the metadictionary Antidote edited by the Canadian company Druide. https://www.antidote.info/.
6 Lily E. Kay, *Who Wrote the Book of Life? A History of the Genetic Code* (Stanford University Press, 2000).
7 Bill Bryson, *The Body: A Guide for Occupants* (Doubleday, 2019).
8 Bruno Latour, *Changer de société : Refaire de la sociologie* (La Découverte, 2006).
9 Xuhui Fu and Raul Rabadan, "Understanding Variants of Unknown Significance: The Computational Frontier," *The Oncologist* 29, no. 8 (August 2024): 653–57, https://doi.org/10.1093/oncolo/oyae103.
10 Isabelle Stengers, "The Earth Won't Let Itself Be Watched," in *Critical Zones: The Science and Politics of Landing on Earth*, ed. Bruno Latour and Peter Weibel (ZKM/Center for Art and Media; MIT Press, 2020), 228–35.

OF SEX, CELLS, AND SIRES

HOW THE CIRCULATION OF REPRODUCTIVE TECHNOLOGIES REMAKES KINSHIP ACROSS SPECIES.

ROXANE GABET SEVERNE
&
SHANA RIETHOF

FROM THE SURROGATE SIRE'S BODY, I KEEP THE UNBORN CALVES

Clic-clic-clic.
Your ears perk up.

Click-click, tchak-krrrr, FFFFsssssh, FFFFsssssh...
Through the blast of the air-conditioning, you hear an all-too-familiar clicking sound.

Click-click. Click-click-click.
A shiver runs down your spine, from skull to tail, your glowing hair making a soft, silky wave.

You sniff the air, your nostrils still sometimes searching for the pungent roundness of straw mixed with urine, a strange nostalgia of an ammoniac era.

Blrbblrbrbrbr. Click-click-click.
Indistinct sounds reach you, a slight tremor of your tail joins them in rhythm, like a thousand-step circle dance that these strange beings sometimes indulge in.

Fzou, fzou, fzou.
The cooled air of the cubicle blasts with each movement of your tail, chasing away the absent flies in a gesture that your whole body remembers.

Click. Click-click. Brlbrlbrl. Click-click.
The computer matches – choosing genetic materials to combine, performances to achieve, inbreeding rates not to exceed, defects to avoid, yields to optimize.

THE HATCHING

Where is the body of your mother? You sit in the dark — unquiet. A drop of sweat pearls on your forehead. A feeling of emptiness slides through your chest whilst you look for a shapeless body — nameless. You are left unlooked, unreckoned, a knot of void in the stomach. An emptiness full of white noise, unanswered questions. Who is going to come and find you? Who will be there, if not your mother? You cannot actually grasp what this word even means — mother —, the air tightens around the consonants — m-th-r — left with a soft gaping O. There is no space around you, nor for the mere existence of these sounds, nor for the flesh of that person itself. But what is a mother anyway? It seems you have forgotten after all. The emptiness feels heavy on your lap. You feel feverish, surrounded by a warm and thick liquid.

Has the body you're looking for disappeared? Or has it ever existed? You start to think it has never even existed. What were you looking for, really? This big bag of emptiness fills your lungs, fills your whole body, fills the room. It is not really a room, it is more like a box. Or a shell. It is way smaller than you thought it was. And suddenly, it feels asphyxiating. Your movements are heavy, you hit the walls. Your body has suddenly grown so much, you don't fit this shell at all. *You keep multiplying inside.*

Click-click. Click-click.
Your jaw moves up and down, biting into the emptiness of this place, repeating the gestures of your ancestors, in a movement that is as much ruminative incantation as it is the jitters of anticipation.

Click-click. FFFsh. Click.
Because when the last clicks are clicked, the last pairings of the day programmed, other noises will be added.

Pam-Ram-Pam-Hiiiii. Brlbrrrlbr.
Your body pulses in your head, blood vessels explode in your oval eyes, an iron taste invades your mouth.
When the herdsman comes, he'll go where the blood flows, where that which is not you lives in you —that which has crossed an ocean, the traces of another, first cousin, semen brothers, testicular colonizer, bovine comrades. What do you call this other that fills you, hormones you, drives you, and immobilizes you in the same gesture?

Click-click-click.
Your tremors intensify as they reach the ankles, the legs, the clean hooves of earthlessness. It shakes inside you. It trembles until it fills the space with this force, surprising them with your power, transforming what worries you into this seemingly tranquil autumn day.
Your molars grind in silence, your hooves rub without movement, in your strength and beauty, you wait for the last click to come.

You proliferate. And you start to shake. You're suddenly blinded by light. Sounds creep in your bubble. The water breaks; a plastic-gloved hand scoops your little body, your exhausted body made of cells. Where is your mother? There is no mother, your matrix is a womb made of glass.

IN THIRTY MINUTES, WRITE A TEXT THAT FOLLOWS THE TRAJECTORY OF THE FEELING OF CONCERN [*INQUIÉTUDE*] IN THE BODY OF SOMEONE, OR SOMETHING: USING THE PRONOUN 'YOU', EXPLORE A SENSE OF UNEASINESS, WORRY, UNREST.

We each wrote our texts based on this prompt in a collective setting in March 2022, during the first session of a doctoral seminar in which we set out to explore what 'Multispecies Reproductive Justice' might mean. Half dedicated to discussing selected readings, and half dedicated to writing, we organized this seminar out of the desire to meet halfway coming from our respective dissertation topics. Reproduction was at the crossing point, with genetic testing around the time of conception and human pregnancy for Shana, and genome editing in cattle breeding for Roxane. Through the prisms of science and technology studies, feminism, and ethnography, we started the seminar with Donna Haraway and Adele Clarke's provocative proposition, outlined in their small book, *Making Kin Not Population*[1], which seemed to connect our mutual research interests.

Let us first go back in time. In the 1980s, Adele Clarke and Donna Haraway met regularly in an unexpected place: the archives of the U.S.-based, pre-World War I National Research Council's Committee for Research on the Problems of Sex. They spent countless hours there, poring over materials that documented how animals were used in physiology laboratories to study human sex and reproduction. Both became interested in how the suffering of monkeys served to craft the tools for disciplining women's reproductive lives. These archives —crisscrossed by "private and public funding apparatuses, industrial interests, animal agriculture, frictions between medicine and biology, and birth control advocates and reproductive scientists"[2] — gave rise to two distinct, yet entangled, bodies of work: *Disciplining Reproduction* for Clarke, and *Primate Visions* for Haraway[3]. With such circulations across species' boundaries in mind, it was not a surprise that a few decades later, they sat together at a conference with other feminists and called out: *Make kin, not babies*!

The call eventually crystallized in the form of a short collective book, *Making Kin Not Population*[4], shaped by the productive tensions among its contributors and published against the backdrop of escalating environmental and social crises. Ecological devastation and industrial farming are at the heart of their concern, as they examine the consequences of unbridled capitalist hubris, coupled with extreme inequalities, racism and sexism. In this context, Haraway and Clarke both felt "deeply troubled" by the growing number of human beings living on Earth, while remaining rooted in a feminist movement long critical of population control programs and discourses, typically advanced by neo-malthusianist and eugenicist actors.[5] They asked other feminists to *not* 'let the boys have it', calling for a refusal to cede demographic issues to technocrats or conservatives. Instead, they sought to lay out the premises of a feminist, antiracist and ecologically concerned engagement with less destructive modes of cohabiting on this planet.

How might we lighten the human presence on Earth without abandoning the framework set by others on reproductive justice[6]? Haraway and Clarke challenge the concept of population, opposing it to making kin, that is, to cultivate multiple forms of non-biological kinship, including with more-than-human beings. In doing so, they raise the possibility of a multispecies reproductive justice, as a challenge to the unequal distribution of resources across people, environments and species. But what does it mean in practice(s)? How might such a proposition be translated across different places and timescapes?

In our seminar, we tried to answer these theoretical provocations by giving them 'flesh' in pragmatic ways. We gathered academic texts that addressed justice at the intersection of human, animal, and ecological reproductive practices. This led us to reconsider notions such as autonomy, consent, and violence. Theorizing from the ground up, we came to see that such 'big' politico-ethical concepts do not easily travel across species' boundaries[7]. Indeed, scholars rarely offer 'positive' accounts of what a multispecies reproductive justice might look like and more often they document its absence through forced labor, extraction, anonymous death, and other forms of structural violence[8]. In search of alternative accounts of human-animal reproductive worlds, we turned to the materialities and histories of reproductive technologies through an ethnographic lens[9]. We also turned to feminist science fiction to imagine other human-animal reproductive entanglements, and to nourish our own writing practices. In fact, some feminist scholars have also experimented with speculative writing to imagine alternative accounts of justice in cross-species relationships.[10] This allowed us to follow another logic: instead of asking only what these technologies *mean*, we began to ask what they *enable* — what practices, relations, and imaginaries they make possible.

In what follows, you can choose what you want to read first: each column departs from one of the texts that opens this chapter. Each of them offers a speculative attempt to build on Clarke and Haraway's proposition. The texts enter into reverberation but must be unfolded on their own. To do so, we looked for fragments of answers in other researchers' work and we present some of the texts we have

read during our seminar. The left-hand column weaves together the farm and the clinic, tracing the circulations that tie them together, both in the history of reproductive sciences, and in current 'transpositions' of knowledge, substances and bodies across species and fields. The right-hand column takes an ethnographic turn: we look at the (dis)continuities between cattle breeding and human assisted reproduction through the traffic of meanings and materialities across both practices. We then present some of the outcomes of the creative writing component of the seminar, and reflect on how it fed back into our academic thinking. In the end, our voices converge once more to envision alternative futures.

PLAYING WITH IDEAS: REPRODUCTIVE TECHNOLOGIES ACROSS SPECIES BOUNDARIES

Writing 'From the surrogate sire's body, I keep the unborn calves'

SURROGACY

This text is addressed to a bull of a new kind, inspired by the development of the 'surrogate sire technology' in recent years. A 'carrier' bull (the male *surrogate*) produces the genetic material of another bull (the male *donor*), through a procedure that modifies its sperm production with genome-editing. In short, a bull carries another bull's semen. Why? In the imagination of the scientists who created this technology, it would allow the import of specific desired genetic traits of Old Jock, an elite Scottish bull, for instance, in Yoani, a Kenyan bull, who is way less productive but more 'adapted' to the local climate, contrary to Old Jock who would not withstand the heat[11].

In current research projects, the donor-receiver trajectwory runs from industrialized countries with a large cattle farming

Writing 'The Hatching'

IN VITRO FERTILIZATION

This text is addressed to a human embryo produced through in vitro fertilization (IVF), a medical procedure that is intended to help aspiring parents fulfill their wish for a child of their own. How are embryos produced? Once ova are retrieved from the body through a surgical procedure, follicles are directly transferred to the lab where oocytes are counted, matured, and combined with sperm. The fertilized eggs are entrusted to the incubator for a few days; technicians carefully check once or twice a day how the embryo — and its cell division — is evolving. After three days, the embryo looks like a mulberry (the morula stage) made up of 16 cells; it fully blooms into a blastocyst a couple of days later, now composed of two hundreds of cells. At one of these stages, embryos are transferred to the uterus. Surrounded by a hard outer layer of cells called the *zona pellucida*, the embryo must break free of infrastructure to the 'Global South'. The aim is to bring the 'fruits' of selective breeding techniques — which are long to come to fruition — to places that don't have the infrastructure to adopt them widely, speeding up the whole process. According to their proponents, the surrogate sire technology could eventually contribute to global food security in the future.

The bull in the text is an imagined elite 'bull stud', kept inside for breeding purposes, collected every couple of days for sperm that will be stored, frozen and sold across the world. Lucky him (or not?), he has been selected by scientists to become the first surrogate sire. The 'clicks' refer to a (not so) fictional world in which computer algorithmic programming would match him with potential mating partners — cows that he will never meet —, in order to verify his renewed fertility.

Yet, if the surrogate sire technology is rare, controversial, and limited to a few experiments in some research centers, the setting of the story itself, the Artificial Insemination (AI) station, is not. On the contrary, this facility dedicated to collecting semen, that is full of solitary bulls — whose worth is quantified in the millions of semen straws that get distributed across the world —, is perfectly ordinary, and almost invisible. Flying under the radar both in academic and in activist spheres — usually focused on the insemination of cows, the female side of exploitation —, it is nonetheless a vital part of cattle farming today. It is this 'shell' in order to implant itself to the lining of the uterus and develop into a pregnancy — a process called 'hatching'.

Once magnified through IVF's looking glass, the processes and products of conception lose their taken-for-granted 'naturalness'[12]: it takes a lot of work, chance and skill to successfully craft a pregnancy that will end in the birth of a much expected child. Crucially, technologies like IVF show that each step of conception can fail along the way, often without much explanation, hence justifying the need for further medical assistance through the use of treatment add-ons.

One of these add-ons is *assisted hatching*, the process described in the story. The embryo is forced into hatching by causing a small crack in the *zona pellucida*, usually around the third or fourth day of embryo development. Assisted hatching artificially mimics and induces a 'natural process', usually hidden from view in the recesses of the womb. Our worried embryo 'feels' its body multiplying; it is suddenly ripped off its shell and extracted from the warmth of the incubator. The human hand collecting the Petri dish — a gloved hand, operating technical gestures – stands for the absence of the embryo's mother. Both stories preempt a feared event — semen collection for the bull stud and assisted hatching for the embryo — imposed by external forces in the lab. Both of these beings were conceived in an artificial environment using IVF techniques. Although

the connecting dot between the farm (since bulls live there) and the laboratory (where their semen is passed through a hatch in the wall to technicians who will analyze it and put it in straw immediately). At the heart of modern reproduction, it is a place that rests on a long history of interspecies circulation.

CIRCULATIONS

We tend to imagine the farm and the medical clinic as two very different spaces: one is muddy and messy, full of animals; the other is white and clean, bubbling and bustling with humans providing and needing care. Yet, the history of reproductive sciences in the twentieth century provides a zone of interplay between agriculture, medicine and biology, showing how none of these fields could have existed as they do now without various forms of 'trafficking' across their borders[13].

Veterinarians, gynaecologists, breeders and biologists are sitting around the same table, next to cows, mice, hyenas, primates, sheep, rats, and many others. We might not always know who or what is on the menu, but we can notice who and what travels across the table. Some people change their seat altogether, as we can see in individual 'hybrid' careers: biologists shifting from working with cattle for the multiplication of their productive offspring, to working with hopeful future parents seeking help in their fertility journey. But mostly, we can observe this circulation in the traffic of different both of them have similar beginnings, they are destined for very different becomings.

FROM COMPARISONS TO REVERSALS

What kinds of connections — beyond historical ones — can be traced between the farm and the clinic? How might we compare the seemingly disparate forces that shape two distinct worlds: cattle breeding and human fertility treatment? An ethnographic approach, such as the one adopted by Amade M'Charek and Grietje Keller in the Dutch context, invites us to examine how similar technologies — such as in vitro fertilization (IVF) and artificial insemination — are embedded in different practices and imbued with different meanings across these settings. At a glance, cattle breeding aims at controlling and improving the quality of the livestock for industrial and commercial purposes (e.g. higher milk production), while human fertility treatment aims to help infertile couples, same-sex couples or childless individuals create a family. Medical means are deployed to serve individual wishes, that to become parents. An easy way to compare these practices would be to note that, whereas human fertility treatment exists to accommodate individuals' *right* for 'a child of their own', reproduction is forced upon cows and bulls *who have never asked for it*. However, we decided to nuance the usually polarized notions of consent and coercion: they impose the same human-centered ethical lens to both cattle breeding and human reproduction.

materials, techniques, and protocols between animal husbandry and human birth management.

Cows' ovaries, pigs' pituitary glands, mares' urine: many substances are taken from animals, alive or dead at the slaughterhouse, by endocrinologists and other scientists in order to produce synthetic hormones, develop superovulation treatments, or collect oocytes for maturation and for In Vitro Fertilization (IVF)[14]. These are some of the transfers between the farm and the clinic — transfers that are not necessarily symmetrical, as the trafficking 'out' of the farm weighs more than in the opposite direction, if only because of the argument of animal experimentation for human reproduction.[15] Yet, such transfers are not only material, they are also epistemic.

The history of artificial insemination is a good case for such transfers, as it is the first reproductive technology to have been used so widely in agriculture. Throughout the twentieth century, it completely transformed breeding cultures. For instance, in the case of the United Kingdom, due to a strong State involvement, AI went from being non-existent and resisted by farmers to becoming a norm and routine in an increasingly industrialized field. But more importantly here, the expansion of AI stations for cattle breeding in the 1950s fostered new networks of reproductive research that overflowed the 'farm' to spill over on the medical clinic. Private birth control advocates funded animal genetics

With that anthropocentric approach, the comparison would end here: bulls are coerced while humans consent. Instead, with a multispecies perspective, we can look at the traffics in meanings across both practices: "technologies, once put into practice, produce categories and sites of intervention and lead to particular configurations, both of humans and of objects of medical intervention".[16]

What if we look at what the same technology 'does' in different settings? According to Amade M'Charek and Grietje Keller, who conducted ethnographies respectively in an IVF clinic and in a Dutch cattle breeding company, both human and bovine IVF aim at improving future progeny by managing risks. Human IVF can be used to prevent genetic defects in humans; bovine IVF, by selecting a diverse range of elite bulls and cows, manages economic hazards by spreading the risks associated with inbreeding. However, financial and commercial aspects also intervene in human IVF: against the backdrop of fast-paced biomedical and technological development, we witness a growing privatization of the fertility industry, the growth of a market for gametes, and stark contrasts in who can access treatments. However, the public discourse on reproductive technologies revolves around desperate couples and medical miracles. On the other hand, medical concerns also pervade the farm as the health and productivity of the cattle are essential to the meat and dairy industry. What collective resources are put into the

centers, interested in their research on chemical contraceptives; and institutes of physiology of reproduction in farm animals produced hormonal preparations for clinical trials and sold them pregnancy diagnosis services. Animal scientists would be consulted by doctors on the effects of vasectomy on humans, or to better understand female oestrus cycles. Farm animal researchers' work "would shed light on problems encountered in the reproduction of humans, and perhaps act as a guide to gynaecological pathologists."[17]

TRANSPOSITION

Such transfers – material and epistemic – have been called "transposition" by sociologist Carrie Friese and historian Adele Clarke. Looking at primates, Adele Clarke shows how along the twentieth century, reproductive scientists made "concrete research offerings [...] to obstetricians, gynaecologists and animal agriculturalists".[18] With the argument of the 'generalizability' of animal physiology, biologists tried to convince them of the usefulness of their research, transposing knowledge from primates to humans, sometimes simplifying their results to de-emphasize interspecific differences. Yet, such transposition would justify the investment in costly research infrastructures (such as a primate colony) that could be used for biomedical advances.

On her part, Carrie Friese brings us to zoos, with cloning being used to conserve endangered species like gaurs, a kind of

production of children and cattle, and who does it benefit? What means are deployed on a global level to improve both human and animal health? 'Matters of concern' between the farm and clinic are porous; some aspects are downplayed in one site while made explicit in the other.

Let's deepen this comparison by staging a role reversal between cows and humans. What if, Scout Calvert asks, cows looked at human breeding practices from their own point of view? From that perspective, our human mating practices, based on personal affinities and mutual attraction, would look quite silly and amusing to a bovine eye. "Humans attribute a lot of their offspring's success in life to genetics but still prefer to leave all but the most obvious traits to chance"[19], would think a cow. Why don't humans keep a genealogical track of genetic and inbreeding risks? Why don't they base their mating success on indicators of productivity (e.g. good udders, high fertility)? Applying this rationality to human reproduction can evoke shady and condemnable practices such as eugenics, but surprisingly, it is not as destabilizing as it seems, as biomedical sciences ceaselessly try to control, predict and optimize the material processes of reproduction.

Conversely, cattle reproduction is not entirely devoid of affect and intimacy, despite the overarching economic purposes of farming. In their inquiry with French farmers on the introduction of 'precision livestock breeding', Catherine Mougenot, Sandrine Petit and Claire Gaillard wonder bovine —*Bos frontalis*— living in Asia. But cloning them requires both basic physiological knowledge on such species (that is sparse and insufficient), as well as enough individuals to act as surrogates to gestate the cloned embryos (but as a species risking extinction, there are very few of them). So, what to do? Transposition it is! Researchers are using 'close enough' domesticated species —in this case, good old *Bos taurus* cows— to make up for the missing gaps: both in terms of physiological data, and in terms of bodies and body parts, acting as surrogates.

Such transfers are not without problems —what they call "recalcitrant processes"— as bodies of different species are not perfectly transmutable, giving rise to successes and limitations, as well as classification difficulties, and their own social and legal ramifications. Here, model animals —common in life sciences, where different hierarchies of life are enacted[20]— no longer only serve as "analogous" bodies, but also as "replacement" bodies. These organisms thus "operate as an 'infrastructure' [...], comprised of available, well-studied bodies that legally and ethically can be deployed to know and reproduce animals of endangered species"[21]. This is what Friese and Clarke call the "infrastructuration" of particular species.

Such infrastructuration is the subtext of the introductory story on surrogate sires, as this technology does exactly that. According to its philanthropic promoters, producing a surrogate sire in the Kenyan if the new tools of genomic selection threaten the 'breeder's vision'. That vision —also a precise skill in its own right, combining multiple clues to determine cows' performances and govern their reproduction— is inextricable from the sensitive dimension of farming. "Knowledge 'about' animals is also knowledge 'with' them, in relationships of reciprocity, negotiation, and often cunning".[22] In the process of breeding, farmers' assessments of utility —whether economic, technical or social— seem as relevant as beauty criteria (their coat, face, stature, or gaze). Relational qualities are inseparable, they add, from "criterias and constraints that sanction the evolution of genetic progress".[23] Logics of care are not reserved to humans only.

THE MATERIALITY OF KINSHIP

M'Charek and Keller also highlight that kinship and lineage play a key role in legitimating both human and bovine assisted reproduction. Reproductive technologies stage and reconfigure these symbolic and cultural relationships through transfers and traffics in biological matter. As anthropologist Sarah Franklin[24] reminds us, biology is neither fixed nor deterministic in defining kinship —it is a dynamic resource that institutions and individuals leverage in different ways. For example, in human reproduction, both maternal and paternal contributions matter in defining kinship. Therefore, when donor sperm is used by heterosexual couples, the genetic contribution of the donor is hidden or downplayed, because kinship is

countryside would be easier than setting up the infrastructure for artificial insemination that would require "well-trained operators [...], specialist equipment [...], an unbroken chain of liquid nitrogen storage, the ability to detect the narrow window of time in which the female is fertile, and to get the right sperm to that female within that time window."[25] The individual surrogate sire then replaces that 'missing infrastructure' by carrying in his body the genetic material of another bull: "the traces of another, first cousin, semen brothers, testicular colonizer, bovine comrades —where that which is not you lives in you". Or, in the scientists' translation: "The recipient male can then disseminate the genetics of the donor by natural breeding, operating as an ambulatory artificial insemination system." [26]

IMAGINATION

While circulations across agricultural, scientific and medical fields can take the shape of material and epistemic transfers, "this middle ground is also an imagined terrain. The links between animals and humans have contributed to defining what was feasible in the future of reproduction. [27]

If animal-human transpositions are made salient through a historical lens, they are still relevant to analyze how the 'control of life' is shifting in modern reproduction today, and what it could become tomorrow. "To what extent does the recent boom of integrated technologies of reproduction and genetics depart from supposed to be a naturalized relationship between the father, the mother and the child. In cattle breeding, the contribution of the 'donor' (here called 'sire') is essential: it is important for a cow to have *the right father*. That is, because sperm is easier to collect and travels faster. The importance of semen lies in its mobility and its marketability: one sire can fertilize thousands of cows in a single year. In that sense, "the materiality of social practices in which reproductive technologies are applied has an impact on how (biological) parenthood is understood and represented."[28] In cattle breeding, the female parent's contribution tends to be trivialized, kinship is represented as a relationship between the male parent and its multiple offspring.

Although similar concerns guide interventions in bovine and human reproduction, differing practices of entanglement and disentanglement take place: the (dis) entanglement of reproduction with financial and societal aspects, the (dis) entanglement of biological substances with representations of parenthood. We can see more clearly how constructions of gender and kinship operate in both sites, sometimes in not so different logics: the IVF human embryo is disentangled from the body of its mother, thereby destabilizing what motherhood means: the genetic contributor, the intended parent, the caretaker? The cow embryo only exists in relation to its father —who stands as a proxy for all his female relatives— and is disentangled from its female the past and confront us with a (not so) brave new biotech world?"[29] Whether it is with surrogate sires, or with other present and future figures, we want to open up a space for imagination that walks the line between a technophobic dystopia, and a risky, but potentially beautiful, technological coevolutionary adventure. What will genomics do to how earthly mammals reproduce? Could cows be oracles of their own kind?

genitor. From that point on, we can ask how these biological entities are valued and hierarchized. *Who "is alive", who "has a life"?* [30] *Whose bodies are made into existence in relation to whom? How do the materialities of reproductive practices affect modes of becoming?*

PLAYING WITH WORDS: FROM SPECULATIVE FICTION TO ETHNOGRAPHIC VIGNETTES

In our seminar, we decided to dedicate half of the time to discussing the readings, and the other half to writing a text while still immersed in the thoughts we had shared.

How to write on seemingly impossible topics? At first, we reached out to feminist science fiction to forge a set of tools for approaching difficult writing themes related to multispecies reproductive justice: cloning, surrogacy, ecological losses, toxicity and so on. Reading Octavia Butler[31] or Becky Chambers[32] next to Sarah Franklin or Michelle Murphy, for instance, created a space to experiment with a less-academic prose, like our texts in the introduction show. We even encountered other academic-speculative experiments, such as Charis Thompson's *Confessions of a Bioterrorist*[33], a short story about cross-species reproduction written by a sociologist. As our research matured, we slowly went from speculative writing to experimenting on fieldnotes and vignettes, using similar prompts for different purposes. And the prompts were really what mattered.

We took inspiration from multiple feminist texts. Take for example Deboleena Roy, feminist theorist and neuroscientist, who wrote a chapter in her book, *Molecular feminisms*[34], that is structured around the steps of a cloning protocol. We were also inspired by anthropologist Margery Wolf in *A thrice-told tale*[35], who wrote the same event in three versions – as fieldnotes, as an ethnographic vignette in an academic paper, and as a fictional story. But most of all, and we recommend its reading to anyone wanting to organize a writing seminar of their own, we used the prompts and exercises offered by SF writer Ursula Le Guin in *Steering the craft*[36]. It is the most exciting and curious invitation to practice the sound of your writing, punctuation and grammar, sentence length, repetition, person and tense of verbs, point of view and voice, indirect narration… through stories.

It was said that the earthly heiress would wait, and that she would not walk on water. She would stand unwavering on a shrinking island, eaten away by the waves.

It was said that if she honored the blue of the sky and of the sea, if she truly called out to them, a response to her call would come from the island. It would then be a membrane being that would emerge, singular and multiple at the same time, fragmented through water and air.

It was then said that everything would still have to be done. Only if their ghosts danced, could life forms on earth endure.

Standing, she scans the horizon.

Zoe McCarthy, 'Clockwork VR: Dawn', 2019, reproduced with permission of the artist

PROMPT: EACH PARTICIPANT HAD TO CHOOSE AN IMAGE FROM A SET OF DIFFERENT ARTWORKS. THE WRITER HAD TO IMAGINE TWO CHARACTERS FROM DIFFERENT SPECIES, MEETING IN THE REPRESENTED SETTING, AND DESCRIBE THEIR ENCOUNTER FOLLOWING ONE OF RAYMOND QUENEAU'S *EXERCICES DE STYLE*.[37]
Here, the chosen style was 'like a prophecy'. The exercise was also inspired by a question asked by Octavia Butler in the introduction of the novella *Bloodchild: "Who knows what we humans have that others might be willing to take in trade for a livable space on a world not our own?"*

LETTER TO MY CLONE

Dear twin,

I'm not mad about Kevin.

When I left you on that train platform, I got a bit crazy, I was nervous. I grew to like you in some way. After all, we're twins. I know you as if I had made you. But *I made you*, in a way. That's why I owe you an explanation.
Will you forgive me one day for leaving you alone?
You don't have to. I know you have a lot of pride. And that you don't like your ego to be scattered, just like me.
But what is innate, and what is not?
You're way more stubborn than I am. And you like mint toothpaste. I hate it.
But I digress.

Maybe I owe you a story, the story of how you were made.
Daddy was into capital investment. He was the living proof that rationality and speculation go hand in hand. When I was born, I had this eye problem – I could have turned blind. He took my cells as a new source of life. So you could grant me your sight.
Pluripotent stem cells, they are called. They come from embryos. They have the power to heal. But, accessorily, you need to create a new human being firsthand.

As a clone, you had to be destroyed. People don't make clones live after a few years anyway these days. You were a piece of replacement. A living medicine so I could live. Like I was a broken car and you were the new tire. But Mom and Dad grew to like you. They found you cute (ain't I cute?).

Daddy told everyone he'd destroyed you, like he'd destroyed others. But he cryopreserved you. You were his living experiment. Better than a brand new tire, right? Like Dr Frankenstein, he crafted you, saw you develop, although you were asleep. You were his second daughter, probably his favorite, as you couldn't speak back.
(Daddy has a fetish for silent women.)

Anyway, one day, the day you woke up, my sister, there was this huge electrical blackout. The machine that kept you like a sleeping beauty all these years broke its waters, and you were released into the world. You sneaked into my room and you know the rest of the story: I hid you, I used you as my double, when I was so fed up with the rest of the human world, or just too lazy to interact.
I know you liked this game: you could prop yourself out into the world, test who you were, who you wanted to become.
Then you slept with Kevin. MY Kevin. And that got out of hand. So when I left, on that platform, I called you 'ugly clone' — I'm sorry about that.
But I'm coming home soon now.
I hope you kept Kevin for me.

Big hugs,
Your twin.

PROMPT: "WRITE A LETTER TO YOUR CLONE".
WE COLLECTIVELY VISIONED EXCERPTS FROM SCIENCE COMMUNICATION VIDEOS AND SCIENCE FICTION MOVIES SUCH AS *'NEVER LET ME GO'* (2010). WE PICKED UP WORDS FROM THESE VIDEOS AND INSERTED THEM IN OUR TEXTS. This writing workshop was imagined and coordinated by our friends and colleagues Simon Vanderstraeten and Jenske Bal.

The next two texts are reworkings of our respective fieldnotes, using creative writing prompts borrowed from Ursula K. Le Guin. Learning literary techniques allowed us to shed new light on the 'mundanity' of everyday life in our field sites — an animal reproductive biology lab for Roxane, and a human genetics lab for Shana. These tools helped us navigate the messiness of fieldnotes and write fieldwork vignettes with greater intention — foregrounding sensory details, shifting perspectives, or weaving technical processes into a literary text. While these texts may seem to move away from reproductive justice as a direct theme, they show how imagination is subtly folded into ethnographic writing (or the other way around).

A ray of light draws a diagonal line, dividing the enclosure in two. Dust floats lazily in the air, a chalky cloud in which the goat 87.423 stands upright, her legs stretched out and her rectangular pupils dilated. She chews her cud, her jaw moving in parallel lines in the shared space, paying no attention to her neighbors. Suddenly, she sniffs, her whiskers quivering with curiosity. The others also stand up timidly. After their smell, it is their sound that signals the arrival of humans —irregular footsteps, a rolling noise on the gravel, and higher-pitched voices rising through the wooden partitions. The door opens, and the sounds are joined by sight: she figures shapes on two legs, which become clearer as they approach, when suddenly there is a *CLICK* —the neon lights go out, and her pupils retract.

After nodding to Carine to press the switch, Stéphane tiptoes into the mutant enclosure, greeting the neighboring goats with a nod of his chin. He approaches the first one and kneels gently beside her flank, one hand on her pelvis. "Well, well..." he says under his breath, inviting his colleague to join him with the portable ultrasound machine, and to help him hold her still. With his other hand, he grabs the probe and tilts the screen. He strokes the thick fur while feeling for the ideal angle to view her belly, moving the probe around. The surrounding semi darkness makes it easier to make out the shapes that appear. With his eyes fixed on the moving black-and-white image, he searches.

She feels both the cold plastic and the warmth of his hand, and grows a little impatient. She watches these humans, all captivated by an object, and starts to move, but is immediately restrained by other hands that hold her firmly but gently. The smooth surface of the white object slides over her belly, searching and pressing, moving backwards. She hears voices answering each other and concentrates on breathing.

He feels the goat's pulse quicken a little, and tries to hurry up to get it over with, but 27 days after insemination, it's not easy to spot the potential embryo that would have developed *in utero*. While his colleagues laugh, he focuses —"I've got a pregnant one", he says in a low voice. Patrick rejoices, Carine notes —"Which number?" "87.423," he replies, taking his eyes off the ultrasound machine to look at the goat's ear, from which hangs a yellow numbered tag, next to the red one marked 'GMO'. "Is everything okay?" asks Patrick. He nods yes, lets go of the goat's sides and moves two steps away, while the goat also steps back, clearly eager to get back to business.

She returns to the back of the pen with a slight hurry. She catches the eye of her neighbor, and the hands and probe move closer to her.

"Okay, next one!"

PROMPT: "CHANGING VOICES" (PART ONE: 'QUICK SHIFTS')
"A SHORT NARRATIVE, [...] [WITH] SEVERAL PEOPLE INVOLVED IN THE SAME ACTIVITY OR EVENT. TELL THE STORY USING SEVERAL DIFFERENT VIEWPOINT CHARACTERS (NARRATORS) [...], CHANGING FROM ONE TO ANOTHER AS THE NARRATIVE PROCEEDS. MARK THE CHANGES WITH LINE BREAKS, WITH THE NARRATOR'S NAME IN PARENTHESES AT THE HEAD OF THAT SECTION, OR WITH ANY DEVICE YOU LIKE."[38]
Describing a scene while switching from the goat's perspective to that of the animal technician was even more perilous than Le Guin's exercise, because it involved constantly risking anthropomorphism in one's description. Yet, this switch connects to core issues in the multispecies humanities literature. How can we articulate the subjectivity of animals on our fieldsites? How can we give a voice, or at least a presence, to those for whom voice and presence are often constrained through the objectification of animals in writing? This writing exercise was a way to experiment with this 'gap' between human and animal consciousness.

JUST LIKE ANY OTHER DAY

"The trick is not to mix the DNA when you extract it from the plasma."
7:59 am, in the laboratory antechamber. The samples arrived last night and were put in the freezer, around twenty plasma tubes placed on a plate. Lisa took them out of the freezer an hour ago. Amelia is watching her, leaning in the doorway, half in the shadow.

To extract: to separate a substance from the body to which it belongs, by various mechanical or chemical processes.

"I'm going to put the plasmas on warm, they haven't thawed yet" says Lisa.
"Do you want me to get the kit out already?" asks Amelia.
"No!" she replies abruptly. Amelia saw a flash of anger in her eyes. She didn't want to sound patronising. She didn't want to act like she knew better. Had she failed her again? She saw Lisa grab the plate of tubes and go into the next room to incubate them for a few minutes in a water bath. A few days ago, they were still

laughing as they affectionately referred to the machine as 'their little microwave'. Why had everything changed so quickly?
To extract, from: Extrahere, from ex: 'out' and trahere: 'to pull'. How can you pull me out of you? When everything you do attracts me?

After two minutes, Lisa returns with the plate and the kit. She sits down in front of the bench where the centrifuge and vacuum pump are lined up. Her gloved hands are shaking. She quickly runs the samples through the centrifuge, taking them out of the plate. "I…" begins Amelia, but the noise of the centrifuge masks her attempt. It sounds like a washing machine. She feels herself being wrung out. Lisa keeps her gaze riveted on the vacuum pump. Into each end of the vacuum pump she carefully inserts a filter column. 1, 2, 3... Up to 23. Twenty-three samples. She does it methodically, but always with care. Not mechanical. That's what Amelia likes about her. Every gesture is surreptitiously different. There's never a dull moment. Lisa still doesn't speak. She then attaches each plasma tube to a filter column.
Suddenly Lisa says: "We're trying to get rid of the white blood cells to isolate the DNA cells. Basically, we're getting rid of the stuff we're not interested in."
Amelia feels like she has been punched in the chest. Why is Lisa talking to her as if she knows nothing about the process? They have been working as junior technicians in the laboratory for two years. They have learnt everything together. Amelia bursts out: "What is that supposed to mean? You want to get rid of me, don't you?"

To extract: to draw out what is essential from a mass that hides or conceals.

PROMPT: "THE EXPOSITORY LUMP" (OPTION TWO: 'THE REAL LUMP')
"THINK OF SOMETHING YOU KNOW HOW TO DO THAT INVOLVES A COMPLEX SERIES OF SPECIFIC ACTIONS: FOR EXAMPLE, MAKING A LOAF OF BREAD, [...] SAILING A BOAT, [...] WRITE A SCENE, INVOLVING AT LEAST TWO PEOPLE, IN WHICH THIS PROCESS IS GOING ON, EITHER IN THE BACKGROUND OF A CONVERSATION OR AS THE LOCUS OF THE ACTION. [...] WHATEVER THE PROCESS IS, MAKE THE VARIOUS STEPS CLEAR TO THE READER, BUT DON'T LET IT APPEAR TO BE WHAT THE PIECE IS ALL ABOUT."[39]
AS A WARM-UP FOR THE EXERCISE, WE GAVE OURSELVES A LITTLE CHALLENGE: FIRST, TO LIST ALL THE OBJECTS NEEDED FOR THE PROCESS WE WERE CURIOUS ABOUT. THEN, TO LIST THE VERBS THAT ARE INVOLVED IN THAT SAME PROCESS. NEXT, TO PICK ONE OF THE LISTED OBJECTS AND FIND TEN RHYMING WORDS FOR IT. FINALLY, TO CHOOSE ONE VERB AND LOOK FOR THE MEANINGS IT CARRIES.
The idea behind this writing exercise was to find ways of incorporating technical descriptions – so abundant in our fieldsites – into ethnographic or fictional writing. STS researchers often find themselves needing to grasp complex, opaque, and sometimes rather dull (because repetitive) technical procedures. We wanted to learn how to work with these elements so they could flow more smoothly in writing, to embed them within the storyline, or even romanticize them (as done here, where a technical process quite literally becomes the backdrop to a laboratory love story – though let us clarify that no such thing happened during fieldwork!). In this case, the process being described is the extraction of DNA from a plasma sample as part of non-invasive prenatal testing (NIPT), which is based on a blood draw from the pregnant woman.

Our seminar allowed us to decategorize theories and ideas about reproduction, sex, and kinship, while paying attention to the multispecies traffics in science to which we owe many of contemporary biomedical innovations. The common thread of our inquiry has been to follow reproductive technologies (AI, IVF, genome editing, genetic selection) and the stories they weave, always interlacing human and animal destinies. Limiting ourselves to only one perspective (the clinic or the farm) would cut these stories short. If we aim to understand, and ultimately answer, Clarke and Haraway's call to make kin not population, with all the multispecies possibilities it brings forth, we must dig these stories up. As Sarah Wilmot puts it, "by incorporating the biological history of animal bodies more fully into our understanding of (agro-)industrialization, we can also uncover some of the origins of power over human reproduction".[40]

Our inquiry led us to not only question relations of power in human and animal reproductive sciences, but also to envision other futures, experimenting with feminist science fiction. On the one hand, we brought the 'real' into the speculative by imagining how the technologies we encountered in the field —as well as their effects on the life of those who are subjected to them— would look like in alternate circumstances: these writing exercises let us play with fictional scenarios, not usually found in ethnographic texts. On the other hand, we brought the speculative back into writing the real: we infused imagination into the concrete, pragmatic descriptions of our field sites through speculative writing exercises. This double movement helped us unpack and play with key concepts and ideas from our seminar (justice, autonomy, consent within interspecies relationships) while always remaining close to the technological worlds we research.

One thing we always made a point of preserving in our writing exercises was that futures don't always need to be dystopian. They can also be witty and hopeful. As a parting gift, we wanted to offer a glimpse into one of these futures, a text written during one of our seminars, and based on Charis Thompson's story, *Confessions of a Bioterrorist*. The prompt for this text was to imagine what would happen ten years after the end of Thompson's story, through dialogue alone (following the "Telling It Slant" prompt by Le Guin)[41]. As a wink to Haraway and Clarke, the text asks: how can we reshuffle the cards between the powerful and the powerless when it comes to managing births on an endangered planet?

— I don't agree, it wasn't in my contract!
— Yes, Miss Becker, it's a sub-clause of article 54, chapter 6, page 87.
— But I had read the chapter on my work obligations, it wasn't stipulated.
— This is not in the section on the obligations of the surrogate, but in the section on the rights of the recipients of the service.
— But who exactly are the recipients of the service? Is it you, the reproductive company, or them?
— I'm not sure what you mean, Miss Becker.
— It doesn't make any sense. If I have to visit them, at least once a fortnight, whose interest is this for? Who exactly is it to reassure?
— I'm still not sure what you mean.
— Of course, you understand!
— Let me ask you again, Miss Becker, what exactly are you offering your services for? Your own financial interest, or for the major humanitarian cause of our foundation, which, I remind you —and this is stipulated in ARTICLE 1, CHAPTER 1, PAGE ONE OF THE CONTRACT— is the interest of inter-species survival?
— I... I'm very… I'm particularly… I'm very concerned about the extinction of species, obviously. Didn't you read my resume? I grew up next to a nature reserve. I saw them, the poachers. Slaughter them. I saw a cub separated from its mother, lying next to it.
— Yes, Miss Becker, it was your personal story that was a major factor in your application being accepted. But I'd like to remind you of the primary reason for our foundation, Virgin 2.0, which was set up 10 years ago. Perhaps you remember?
— Yes, the discovery that inter-species gestation is possible. And concomitantly, the realization of the deleterious impact of human beings on the accelerated disappearance of primates.
— Yes, and what did that lead to, Miss Becker?
— To the first pioneering inter-species surrogacy programs. To 'repair' the damage that humans have inflicted on primates.
— And what does this involve, Miss Becker, as stipulated in chapter 6 of the contract?
— Uh-, well, that... Inter-species gestation always poses significant health risks for pregnant human females. Hence the program's substantial financial compensation.
— No, you're all about the money, Miss Becker! You make me doubt your true altruistic intentions!
— I'm very altruistic. The little one separated from his mother, I told you. I grew up on a farm. My mother died of a prion disease when I was a child. I'm an orphan

too, you see. I know what it's like to lose what's dearest to you. To lose a part of yourself. I'm very aware of the cause.

— Yes, and having grown up on a farm, you know the importance of multispecies relations. To take care of these beings thanks to which we ourselves live. Hence the sub-clause of article 54. The bonobos are allowed to visit once a fortnight so you can bond with them. Understand their vision of the world. They have a lot to teach you. It's their babies you're carrying, I remind you.

— Yes, but it's the image of your company that I represent. And it's a baby bonobo for the zoo that I'm carrying. For the financial success of your company — er, your foundation as you call it. What exactly will become of these baby bonobos? Will they suffer the same fate as their parents, locked up in a gilded prison, a showcase for your company's success?

— I don't like what you're implying, Miss Becker.

— I'm not sure I want to donate my baby bonobos to the zoo anymore, Mrs. Richards.

1 Adele E. Clarke and Donna Haraway, eds., *Making Kin Not Population: Reconceiving Generations* (Prickly Paradigm Press, 2018).

2 Donna Haraway, "Making Kin with Adele: From Pathologizing in Vienna to Collaborating in Denver," *Science, Technology & Human Values* 49, no. 6 (2024): 1179.

3 Adele Clarke, *Disciplining Reproduction. Modernity, American Life Sciences, and "the Problems of Sex"* (University of California Press, 1998); Donna Haraway, *Primate Visions: Gender, Race, and Nature in the World of Modern Science* (Routledge, 1989).

4 Clarke and Haraway, *Making Kin Not Population.*

5 Haraway, "Making Kin with Adele", 1181.

6 Reproductive Justice is a collective movement initiated by Indigenous women and women of color in the United States. Emerging in response to dominant reproductive politics — largely focused on individual rights and the abortion debate — these activists drew attention to the broader social inequalities that constrained their reproductive and familial lives. Centered on community-led solutions, the movement emphasized that, rather than only fighting for the right not to have children, their core concern was securing the conditions under which they could bring children into the world and raise them with dignity and safety, particularly in the face of social crises, epidemiological threats, and environmental degradation. See: Zakiya Luna and Kristin Luker,"Reproductive Justice," *Annual Review of Law and Social Science* 9, no. 1(2023): 327–52.

7 Vinciane Despret, *Que diraient les animaux, si… on leur posait les bonnes questions ?* (La Découverte, 2012); Gabriel Rosenberg, "How Meat Changed Sex: The Law of Interspecies Intimacy after Industrial Reproduction," *GLQ: A Journal of Lesbian and Gay Studies* 23, no. 4 (2017): 473-507.

8 Sophie Chao, Karin Bolender and Eben Kirksey, eds., The Promise of Multispecies Justice (Duke University Press, 2022); Yamini Narayanan, *Mother Cow, Mother India: A Multispecies Politics of Dairy in India* (Stanford University Press, 2023); Maan Barua Plantation *Worlds* (Duke University Press, 2024); Deborah Bird Rose *Wild Dog Dreaming: Love and Extinction* (University of Virginia Press, 2011); Sharmila Rudrappa, "Land, Women and Techno-Pastoral Development in Southern Karnataka, India," *Reproductive Biomedicine & Society Online* 7 (2018): 141–49; Michelle Murphy, "Alterlife and Decolonial Chemical Relations," *Cultural Anthropology* 32, no. 4 (2017): 494–503.

9 Cristina Grasseni, "Managing Cows: An Ethnography of Breeding Practices and Uses of Reproductive Technology in Contemporary Dairy Farming in Lombardy (Italy)," *Studies in History and Philosophy of Science* Part C: Studies in History and Philosophy of Biological and Biomedical Sciences 38, no. 2 (2007): 488–510; Amade M'Charek and Grietje Keller, "Parenthood and Kinship in IVF for Humans and Animals: On Traveling Bits of Life in the Age of Genetics," in *Bits of Life. Feminism at the Intersections of Media, Bioscience, and Technology*, ed. Anneke Smelik and Nina Lykke (University of Washington Press 2008), 61-78; Carrie Friese and Adele E. Clarke, "Transposing Bodies of Knowledge and Technique: Animal Models at Work in Reproductive Sciences," *Social Studies of Science* 42, no. 1 (2012): 31–52; Tamar Novick, *Milk & Honey: Technologies of Plenty in the Making of a Holy Land* (MIT Press, 2023).

10 Charis Thompson, "Confessions of a Bioterrorist," in *Playing Dolly. Technocultural Formations, Fantasies, and Fictions of Assisted Reproduction*, ed. Ann Kaplan and Susan Merrill Squier (Rutgers University Press, 1999), 189–219; Donna Haraway, *Staying with the Trouble: Making Kin in the Chthulucene* (Duke University Press, 2016).

11 Old Jock is the first bull recorded in the Scottish herd book of Aberdeen Angus breed in the 19th century, and Yoani is a Boran bull (a Zebu breed in eastern Africa) whose semen is sold by the Kenya Animal Genetic Resources Centre. For this small fictitious case, I took inspiration for the names of bulls from Scotland and Kenya as the surrogate sire technology is being developed at the Roslin Institute in Edinburgh (as well as in universities in the United States of America), and in collaboration with the University of Nairobi in Kenya.International Livestock Research Institute, "Scientists in Africa explore use of surrogate sires to improve small ruminant breeds" (2021). Visited on August 19, 2025. https://www.ilri.org/news/scientists-africa-explore-use-surrogate-sires-improve-small-ruminant-breeds).

12 Sarah Franklin, *Embodied Progress: A Cultural Account of Assisted Conception* (Routledge, 1997).

13 Clarke, *Disciplining Reproduction.*

14 Haraway, *Staying with the Trouble.*

15 Jean-Paul Gaudillière, "The Farm and the Clinic: An Inquiry into the Making of Our Biotechnological Modernity," Studies in History and Philosophy of Science Part C: *Studies in History and Philosophy of Biological and Biomedical Sciences* 38, no. 2 (2007): 521–29.

16 M'Charek and Keller, "Parenthood and Kinship", 64.

17 The history of the development of Artificial Insemination in the U.K. is developed in details in: Sarah Wilmot, "From 'Public Service' to Artificial Insemination: Animal Breeding Science and Reproductive Research in Early Twentieth-Century Britain," *Studies in History and Philosophy of Science* Part C: Studies in History and Philosophy of Biological and Biomedical Sciences 38, no. 2 (2007): 434.

18 Friese and Clarke, "Transposing Bodies", 37.

19 Scout Calvert, "Making Babies With Cows," in *Living with Animals: Bonds across Species*, ed. Natalie Porter and Ilana Gershon (Cornell University Press, 2018): 146.

20 Noémie Merleau Ponty, "A Hierarchy of Deaths: Stem Cells, Animals and Humans Understood by Developmental Biologists," *Science as Culture* 28, no. 4 (2020): 492–512.

21 Friese and Clarke, "Transposing Bodies", 43.

22 Catherine Mougenot, Sandrine Petit and Claire Gaillard, "Le « coup d'œil » de l'éleveur est-il menacé par l'élevage de précision ?" *Activités* (Online) 17, no. 2 (2020): 4.

23 Mougenot, Petit and Gaillard, "Le coup d'œil", 8.

24 Sarah Franklin, *Biological Relatives: IVF, Stem Cells, and the Future of Kinship* (Duke University Press, 2013).

25 International Livestock Research Institute, "Scientists in Africa".

26 Gus R. McFarlane, Hamish A. Salvesen, Anna Sternberg and Simon G. Lillico, "On-Farm Livestock Genome Editing Using Cutting Edge Reproductive Technologies," *Frontiers in Sustainable Food Systems* 3 (2019): 4.

27 Gaudillière, "The Farm and the Clinic", 524.

28 M'Charek and Keller, "Parenthood and Kinship", 75.

29 Gaudillière, "The Farm and the Clinic", 522.

30 Merleau-Ponty, "A Hierarchy of Deaths".

31 Octavia Butler, *Bloodchild and Other Stories* (Seven Stories Press, 2005).

32 Becky Chambers, *To Be Taught, If Fortunate* (Hodder & Stoughton, 2019).

33 Thompson, "Confessions".

34 Deboleena Roy, *Molecular Feminisms: Biology, Becomings, and Life in the Lab* (University of Washington Press, 2018).

35 Margery Wolf, *A Thrice-Told Tale. Feminism, Postmodernism, and Ethnographic Responsibility* (Stanford University Press, 1992).

36 Ursula K Le Guin, *Steering the Craft: A Twenty-First Century Guide to Sailing the Sea of Story* (Mariner Books, 2015

37 Raymond Queneau, *Exercices de style* (Gallimard, 1947).)

38 Le Guin, *Steering the Craft*, 78.

39 Le Guin, *Steering the Craft*, 97.

40 Wilmot, "From 'Public Service' to Artificial Insemination", 436.

41 Le Guin, *Steering the Craft*, 84.

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ecoWlogy
coWde
decoWding
Michel FoucoW
coWorking
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