Purity

Its Role in Livestock Breeding and Eugenics, 1880–1920

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ABSTRACT *This article uses the concept of purity to explore the thinking of purebred animal breeders and that of eugenicists in Britain and North America between 1880 and 1920. It begins with an explanation of why such a study is important and continues with the historical background of purity's role in animal breeding over the nineteenth century and an assessment of the theoretical foundations of Francis Galton's eugenics. The article argues that the shared concern with pedigree keeping, which characterized both purebred breeding and eugenics, made it easy for historians to assume that the two fields were more connected than they actually were. In fact, the basis for purity in animal breeding—namely, inbreeding and marketability—could not migrate to eugenics. Pedigree use in animal breeding (inbreeding, consistency, and marketability) actually had little in common with pedigree use in eugenics (evidence of inheritance via statistical quantification). Unpacking this historic connection between animal breeding and eugenics has significance today for such disciplines as animal breeding itself, genetics, politics, and ethics.*

KEYWORDS *genetics, breeding, purity, Britain, North America*

Many observers today consider the idea of "purity" in any breeding activity as morally objectionable and genetically unsustainable. But over the years the notion of purity has played a complex role in the evolution of many breeding strategies, whether intended for use on nonhuman or human animals. The implications of purity within either framework, however, have remained elusive. This article explores purity's function in animal breeding (with an emphasis on the purebred system) and eugenics to help clarify purity's role in the dynamics of both. The concept of purity in the thinking of animal breeders is evaluated against that of Francis Galton and his fellow eugenicists in Britain and North America from the late nineteenth to the early twentieth century. The article confronts the meaning of purity by outlining, first, the historical background to purity's role in animal breeding over the nineteenth century, and second, the theoretical foundations of eugenics with an emphasis on Galton's views and reactions to them. The article then discusses the effects of Mendelism on the attitudes of animal breeders and

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eugenicists toward purity. An assessment follows of the social reach of the ideology of purity in breeding. The article concludes by reflecting on the nature of purity in the theoretical development of both animal breeding and eugenics, as well as commenting on its role in what is called "new" eugenics.

A few words of explanation on the structure of the article might be in order. First, my concentration on the situation in Britain and Galton's theories, with reference to North American views in relation to them, is designed to provide examples of attitudes within what was a widespread eugenic world in the late nineteenth and early twentieth centuries. There was considerable commonality in the opinions of North American and British eugenicists, with respect to problems and to Galton's ideology. What could appear to represent major differences—for example, the allegiance to Mendelism versus biometry in pedigree research—did not divide them in any substantive way when it came to supporting the pursuit of improvement or purity. There were differences in approaches to attaining purity, but the ideology behind these approaches was much the same. It should be remembered, too, that many basic approaches in animal breeding, as well as the desire for purification of human populations, existed in other parts of the world—New Zealand, Australia, and South Africa, among others.[1] Second, in the interest of pinpointing purity within a broad range of eugenic thought across countries, I provide a simplified account of eugenic ideology. In this article, I track the influence and strength of the purity idea within a broad and complicated framework. I sacrifice depth for breadth because this is the only way to show clearly that purity was not a vague, amorphous theory within animal breeding circles that was then carried over to eugenics. Rather, purity was an important concept for animal breeders quite distinct from its application within eugenics.

An assessment of the meaning of purity within both contexts is particularly imperative because of trends in contemporary scholarship. Until recently, many scholars had assumed that eugenics emerged out of animal breeding in a cause-and-effect fashion. In the last two decades, a new trend has emerged that emphasizes the parallel development of eugenics and animal breeding, with purity as the primary linking concept.[2] For example, recent studies sponsored by the Max Planck Institute have argued that both animal breeding and eugenics were merely parts of a broader knowledge regime dating back to the Enlightenment.[3] These studies placed eugenics and animal breeding within a much larger picture in which medical knowledge and Darwinian natural history also fit.

Subsequent studies have built on this parallelism theory, which avoids the cause-and-effect linkage and instead emphasizes the importance of purity as

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the major commonality between the two. In a study of hereditary thought in nineteenth-century Canada, Riiko Bedford treats eugenics as just one part of a world interested in heredity from a practical, social, and political point of view. Bedford looks at animal breeding practices and theories by reading what chicken breeders wrote and what farmers read in the farm press. But Bedford relies on the idea that similar purity outlooks were fundamental to both breeders and eugenic/social reformers.[4] Similarly, in an article primarily concerned with purity (or thinly veiled eugenic racialization) and improvement in cattle breeding, Gabriel N. Rosenberg argues that it is a mistake to say one caused the other. Rather, like Bedford, he believes that positions toward heredity were simultaneously produced in both fields. Rosenberg establishes the shared views of purebred livestock breeders and eugenicists through an analysis of material generated by individuals with conjoined purebred and eugenic concerns.[5] Much of his research was based on the thinking and writing of United States Department of Agriculture (USDA) agricultural experts who were supporters of both purebred and eugenic breeding.

Modern scholarship, then, implies the importance of purity in both eugenics and animal breeding without exploring in depth the meaning and implications of purity itself. Appreciating what purity meant in animal breeding is essential before making any comparison to eugenics.

Animal Breeding and Purity

Animal breeding is an ancient occupation. Attention to the practice and a more organized structural method evolved over the late seventeenth and eighteenth centuries in northern Europe. The nineteenth century saw further important developments in breeding methodology. Darwinism ignited a new approach to breeding through the development of a closer connection between natural selection and artificial selection.[6] Some animal breeders, especially horse breeders, were quick to associate Darwin's theories with their artificial-selection strategies.[7] Darwin studied different breeding programs, becoming fully aware of the hybridizing experiments of naturalists and the strategies of pigeon breeding, but was particularly impressed with the effects (and breeding methods) of a different system—namely, purebred breeding. That animal breeding methodology, accepted by agricultural experts as the modus operandi for improvement breeding of cattle and sheep (and shortly after that time other animals such as horses and dogs), attracted Darwin's special attention in his 1868 *Variation of Animals and Plants under Domestication*. "Why have pedigrees been scrupulously kept and published of the Shorthorn cattle, and more recently of the Hereford breed?" he asked. "Is it

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an illusion that these recently improved animals safely transmit their excellent qualities even when crossed with other breeds? Have the Shorthorns, without good reason, been purchased at immense prices and exported to almost every quarter of the globe?" Clearly, he added, "hard cash down is an excellent test of inherited superiority."[8] Darwin's fascination with the monetary power of purebred breeding seems to have clouded his mind when it came to understanding how heredity worked. Earlier, in *On the Origin of Species*, he had acknowledged that "the laws governing inheritance are quite unknown."[9] Regardless of the flaws in his 1868 views, Darwin's basic association of purebred breeding with science would be long-lasting.

Viewing artificial selection in light of attitudes toward natural selection would open doors to the future correlation of animal breeding with science. The association of the purebred breeding method with what would later become scientific questions would be ongoing from that time and until well after the rise of Mendelian genetics in 1900. This general attitude brought breeding methodology itself into the complicated picture of evolving approaches to biology. Since purebred breeding would take on the aura of science and would ultimately be revered by eugenicists who designed breeding strategies for use on humans, the system's dynamics—including the concept of purity— are fundamental to the eugenics story. Understanding the development of purebred breeding is, therefore, critical.

The rising importance of the animal trade in international markets clearly verified that Darwin had been correct about the monetary impact of the purebred breeding method. It could be lucrative, and that fact alone attracted attention. The method had been developed by the British livestock breeder, Thomas Bates, through his work with Shorthorn cattle, and purity was central to the method from its beginnings in the 1830s. The system reflected the complicated intertwining of two separate breeding outlooks: the principles of Thoroughbred horse breeders and those of Robert Bakewell and the Enlightenment livestock breeders. Bates capitalized on the cultural attitudes of Thoroughbred horse breeders by focusing on their purity vision, and more particularly on the way that purity received validation. Purity ideology in the Thoroughbred originated with attitudes toward the breeding methodology of crossing seventeenth-century Eastern-imported stallions on local mares. The ongoing emphasis on the importance of such practices created an enduring culture of Thoroughbred breeding.[10] That culture placed a high value on purity and was reinforced by a documentation scheme (the recording of horse ancestry via pedigrees), thereby authenticating both the culture and the purity ideology.[11] The purity-pedigree structure proved to be powerful

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in the advancement of the Thoroughbred and brought with it important financial implications. The Thoroughbred horse breeders had invented a powerful marketing tool: public pedigree keeping coupled with purity ideology. Bates recognized that fact more clearly than most of his contemporaries, and he also added a new dynamic to the story: inbreeding as a selection tool, and, more particularly, the use of pedigrees to document that inbreeding. He subsequently defined inbreeding as purity, a connection that was both new and effective.

Prior to Bates, the Enlightenment breeders, primarily led by Robert Bakewell, had practiced inbreeding to establish uniformity of type. Inbreeding for Bakewell and his cohorts was not driven by purity ideology; instead, breeders practiced it because it brought uniformity across populations or herds.[12] While under Bakewell inbreeding had meant quality because of consistency of type across groups, under Bates the meaning became dichotomous: inbreeding meant purity in individuals, and in a more nebulous way implied consistency of type across groups. Purity-inbreeding also implied lack of contamination, an outlook that meshed well with Thoroughbred breeding culture.[13]

Bates's promotional skills became well known as early as 1820, and he quickly attracted buyers among members of the landed aristocratic class in Britain, including Lord Althorp. After a dinner party in 1820 Althorp, who greatly admired Bates as well as his cattle, turned to a friend and said: "A wonderful, wonderful man! He might become anything—Prime Minister."[14] It wasn't long before Bates attracted American importers as well. In 1833, when Felix Renick of the Ohio Importing Company went on a buying trip to England looking for improved cattle, he decided to purchase only animals with pedigrees. He looked at other cattle types and believed many of them to be of equally high quality but settled on Shorthorns, because they alone of any livestock (outside Thoroughbreds) had a public registry system. Renick recognized that pedigrees played a huge role in enhancing the innate value of an animal.[15] It did not hurt that Bates actively courted the American.

Bates masterfully structured his purity vision so that it had three different, valuable, and even separate thrusts, all of which rested on the foundations of, and were entangled with, pedigree keeping: breeding methods, breeding aims, and marketing of breeding. Purity reflected breeding for excellence in the individual and implied consistency of type; purity was an aim of breeding for various reasons; and ultimately purity meant marketability. Purity, in effect, could even be used to define the meaning of breed, because the idea of "breed" rests on consistency of type. Breeding methods designed to promote

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purity, and therefore maintain consistency, have continued to dominate many animal industries. Bates's vision of purity as a breeding aim could be seen, for example, in efforts to promote authenticity to historic type. It was in a purity linkage to trade or monetary concerns, however, that we perhaps see Bates's greatest achievement. By associating either a purity breeding method or a purity breeding aim with this third factor, the market, Bates created a powerful system which rested on an interconnected and linked dynamic. Each thrust complemented (or was integrated with) the others. It is true that Burke's Peerage had been published by the time Bates's triple vision of purity arose, and that Bates likely knew of the public's interest in aristocratic genealogy (or what might be termed as the breeding of the nobility). The fact that he capitalized on purity as a three-pronged feature of animal breeding under a pedigree system, however, suggests that animal purity, within the purebred structure, was multifaceted. Examples of how that intertwined purity operated within the system are endless. It explains the growth of the transatlantic trade for purebred cattle and horses in the late nineteenth century, for example. In 1885, an American importer of French draft horses described this pattern succinctly when he wrote: "Registration furnishes something of a guarantee of purity of blood; and it is purity of blood that persons who buy imported stock are now almost universally insisting on."[16] Standards set for pedigrees took on supreme importance in the purebred marketplace and had many ramifications. The general move to the idea that purity defined quality could even bring about the demise of breeding practices known to produce good stock. The declining welfare of Clyde/Shire cross horses in North America and the shift to different phenotypic style in Percherons indicated how significant pedigrees could be to breeding techniques and to the development of breeds from what had been types, especially when combined with notions of purity in pure breeds.[17]

Purebred breeding, in essence, superseded the two systems that went into its development. The deviation from Bakewellianism would become increasingly forgotten. The basic selection tool in Bakewell's system, breeding by progeny test, for example, would not reemerge in any widespread way for the larger animals until the rise of quantitative genetics after the mid-twentieth century. Public pedigree keeping, the fundamental selection tool of the Thoroughbred breeders, would become almost another definition of purebred breeding, making it easy for Thoroughbred horse breeding to adopt the aura of purebred breeding. To put the situation succinctly, purebred breeding replaced Bakewellianism, and absorbed Thoroughbred horse breeding into its ranks.

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Pedigrees might define purebred breeding, but they could be utilized in many ways within that framework. Appreciating pedigrees as devices to quantitatively control inheritance, for example, was one way of approaching them. Analyzing pedigrees with that in mind had become quite common as early as the 1860s among practical breeders in North America and Britain. Ancestry charts or pedigrees were believed to show a critical relationship between generational input and outcome of progeny. Viewing pedigrees in this fashion, it should be pointed out, did not conflict with following the basic breeding principles under the purebred system. In fact, a statistical way of assessing pedigrees was intended to promote purebred ideology, which was founded on careful inbreeding, desire for consistency, and the drive to achieve marketability. Considerable flexibility always existed within the method when it came to personal breeding decisions, a situation indicating the complexity of pedigree involvement in breeding. Various breeders used pedigrees to develop theories about heredity information potentially embedded in such recording, inventing complicated statistical analyses in the process. A good example of a thoughtful analysis of generational change as evidenced in pedigrees for breeding purposes was that of American fancy chicken breeder I. K. Felch. Even if, strictly speaking, Felch was not a purebred breeder (he did not register his pedigrees in a public book), he followed purebred principles, and in the process he came to view pedigrees as diagrams explaining heredity in a quantitative way. Felch argued that by recombining the blood of an original breeding pair from different mating combinations over generations of their descendants, the heredity of the original pair could be regenerated in various blends. One could, therefore, inbreed (or line breed, according to his definition of the term) forever.[18] No outside blood need be introduced.[19] With careful selection Felch could shift the hereditary makeup of the group he desired to work with, by changing the relative input of either original parent. He concluded as follows: "As long as you can create groups representing half of the blood of each of the original Adam and Eve of your flock as reservoirs from which you can draw new blood for your mating in such a way that each group of chicks will show a change in their blood from that of their sires and dams. That is the secret of inbreeding."[20] As Felch put it, "We can mix the blood of our birds as easily as we mix paints that give us different tints of color."[21] His ideas and charts would be quoted and requoted (and sometimes presented with a few modifications that really were "little more than a steal") throughout his life and after his death in 1918 at the age of eighty-four, even though momentous changes were shaking the world of hereditary science and practice by that time.[22]

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Pedigree keeping was fundamental to Thoroughbred breeding, and horse breeders also established ways of looking at pedigrees in terms of statistical hereditary information. Two examples suffice to demonstrate this pattern: dosage theory and the figure system, which were developed in France and Australia, respectively, and became part of Thoroughbred horse breeding culture in many countries of the world. Dosage theory originated from the work of a Frenchman, J. J. Vuillier. In 1902 he examined the pedigrees of successful racehorses to the twelfth generation and noted there were similarities in that fifteen stallions and one mare appeared in all of them with roughly the same frequency. He devised a sort of formula or recipe for creating the ideal racehorse. If one selected a horse that lacked the relative "dosage" needed to recreate a needed pedigree, the animal mated to that horse should compensate for that deficiency through his or her pedigree, because a foal represented a blend of hereditary material. The other pedigree-based generational schema, the figure system, was based on the nineteenth-century work of Bruce Lowe, an Australian who spent years tracing every mare appearing in pedigree records back to her "taproot" in the original pedigree record. He then gave numbers to each of these families, ranging from one to forty-three, and related mares to male winners of the great races over time.[23]

Clearly, by the late nineteenth century some breeders believed statistical information through pedigree research served as one way to promote the aims of purebred breeding. It would primarily be this aspect of pedigree use that attracted the interest of Francis Galton.

Francis Galton: Animal Breeding and the Foundation of Eugenics

Over the second half of the nineteenth century, Francis Galton became fascinated with both Darwinism and domestic animal breeding. Born in 1822 and a cousin of Darwin, Galton began his academic career by studying medicine and mathematics at Cambridge University. The issue of quantification would be part of any project he undertook after that time. Interested in geography from a quantitative point of view in his early life, he subsequently turned to address the problem of inheritance via natural selection and contingently artificial selection.[24] Galton spent a considerable amount of time gathering pedigree information on characteristics such as coat color over generations and from a quantitative point of view, amassing an immense amount of material generated by practical breeders in the form of ancestry records of dogs, horses, and cattle.[25] He was attracted to animal-breeder pedigrees because they supplied him with data that allowed for an assessment of various characteristics inherited over generations.[26] His work along this line led him to

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the formulation of his "ancestral law," fully developed by 1897 (but initially formed in 1865). The law, "The Average Contribution of Each Several Ancestor to the Total Heritage of the Offspring," was published in the *Proceedings of the Royal Society* in 1897. It stated "that the two parents contribute between them on the average one half of the total inheritance of the offspring; the four grandparents one quarter," and so on. "Furthermore," Galton added, "it is reasonable to believe that the contributions of parents to children are in the same proportion as those of the grandparents to the parents."[27] Pedigrees, then, explained how the hereditary input of ancestors could be understood. It was a matter of percentages in relation to generations.[28] For Galton this was the basis for understanding heredity, and it would be his guiding star when it came to any form of artificial selection.

Galton's hereditary ideas involving statistical analysis emerged not just from pedigree research but also from the direct input of animal-breeder analytic theory, although it is difficult to tell which source was more influential. The quantitative approaches of Felch and Galton to inheritance were strikingly similar (even if Felch used his charts to control and practice inbreeding, and Galton did not), but there is no evidence that Galton was even aware of Felch's system.[29] It is possible that Galton independently reached the same conclusions as breeders like Felch due to his lifelong concern with statistical quantification. Still, the ancestral law itself owed much to the input of data generated and analyzed by Everett Millais, a purebred basset hound breeder in England. In *The Theory and Practice of Rational Breeding*, Millais worked out charts showing generational effects of inbreeding and outcrossing within the basset hound breed. Millais argued that inheritance, particularly of coat color, could be calculated by assessing ancestral charts on a percentage basis. Published in 1889, the study would form part of Galton's evidence supporting his law.[30] The formulation of the law, however, regardless of its direct provenance from this breeder's studies, took Galton's evolving system into a different realm. Breeders had been using pedigrees quantitatively for breeding (or selection) purposes, based on the workings of unknown hereditary laws.[31] Galton used pedigrees to explain those laws. In other words, when he crafted a theory based on pedigree evidence and then labeled that theory as a law that explained complicated contemporary views in relation to speciation, Galton utilized aspects of breeder thought to serve his own theoretical purposes.

Believing that his law explained why breeder systems worked, Galton reasoned that it could also shape the practices of stock breeders.[32] He went on to suggest ways of enhancing existing breeding strategies by taking into

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consideration the law's implications. For example, since he assumed the physicality of past generations was critical for breeding decisions made in the present, Galton advocated the preservation of ancestral photographs as part of the pedigree registering process for animal breeds, to establish with more precision how persistent certain physical features could be. He was particularly concerned with Thoroughbred horses, but he recommended applying the strategy to other breeds as well.[33] Responses from practical breeders indicate that they saw flaws in this approach. In 1898, W. Housman, a well-known authority on practical cattle breeding (he had written a book on the subject in 1876), commented in the British *Live Stock Journal*: "At the best, the photographs could show only the outside of each animal, and certainly not more than one-half of that. . . . [Furthermore,] the inheritance of even outside characteristics depends much upon things within, things quite beyond the reach of photography."[34] Galton, highly displeased with such public commentary about his research, responded by stating he was engaged in "making experiments on photographing and measuring cattle, and should be very grateful for *private* communications containing helpful advice from breeders of stock, and from animal photographers."[35] Galton also tried other ways of applying his law: for example, to interpret what pedigrees could reveal about the inheritance of speed, he assessed in detail the pedigrees of the American Standardbred, but he did not reach any definite conclusion.[36]

Galton's plans for revising animal breeding were not well received by breeders, who felt he lacked a complete understanding of both the aims of breeding and the factors affecting breeding decisions. Since Galton focused primarily on the quantitative implications of breeding, and breeders made selection decisions based on various considerations beyond statistical data, it is not difficult to see why they had little faith in his suggestions. When compared to the complexity of animal breeder thought and motivation, Galton took a relatively simplistic approach to both pedigrees and breeding itself. Breeders would become increasingly disenchanted with eugenic breeding as well as any potential relationship they might have with eugenicists. For example, the virtual eugenicist takeover by 1920 of the American Breeders' Association, an organization originally devoted internationally to both animal breeding and eugenic interests, resulted in breeders avoiding the association.[37] Eugenicists, in turn, sometimes commented on the apparent lack of interest among breeders in eugenics. "The American farmer, as a rule, takes great pride in improving his live stock," the *Journal of Heredity* noted in 1916, "but never once seeks to improve the coming generations of his own household."[38]

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Regardless of breeder disenchantment with eugenics, it was an easy step for Galton to suggest that his law was as useful for human breeding strategies as for animal breeding strategies. His work on human inheritance involved human-animal comparative studies, calculating mathematical measurements from pedigree data documenting human ancestry concerning eye color and animal ancestry concerning coat color. Imagery also provided usable data for Galton in such studies. In 1883 he formally named his human project, well under way by this time, as the eugenics movement. Eugenic strategies, Galton believed, should involve the choosing of breeding mates (marriage partners) by taking his ancestral law into account. Improvement would take place over generations.[39] In 1886 Galton began to argue that quantification itself formed the basis of a separate academic discipline. His theories and ideas received considerable validation after the publication in 1889 of his second book, *Natural Inheritance*.[40] The great statistician Karl Pearson and the marine biologist W. F. R. Weldon were both impressed with Galton's idea of using statistical analysis to study patterns of inheritance. In the 1890s Pearson took over the crude statistical tools that Galton had developed and refined them to look in many ways like modern statistics.[41] The journal *Biometrika*, established in 1901, furthered that study with a special focus on evolution.[42]

In the 1901 Huxley lecture, published in *Nature* and therefore read across the Western world, Galton set out his views for how improvement could be achieved in humans. He said, "The possibility of improving the race of the nation depends on the power of increasing the productivity of the best stock. This is far more important than repressing the productivity of the worst."[43] He offered few suggestions (other than vague comments about marriage regulation through pedigree collection) on how artificial selection could be done in a human breeding program.[44] Clearly, though, he favored positive eugenics, or the breeding of more superior humans, rather than negative eugenics, which supported restrictive breeding policies aimed at inferior groups. Eugenics was also a question of religion and racial nationalism for Galton. "An enthusiasm to improve the human race is so noble in its aim that it might well give rise to the sense of a religious obligation," he stated. Furthermore, "to no nation is a high human breed more necessary than to our own, for we plant our stock all over the world and lay the foundation of the dispositions and capacities of future millions of the human race."[45]

Galton reiterated his position in his introductory speech at a conference which took place in 1904 in London's School of Economics and published in the *American Journal of Sociology*. In keeping with his concern with quantifi-

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cation, he stated, "The practice of eugenics should . . . raise the average quality of our nation."[46] The move to improvement via breeding was a question of changing percentages. For Galton, shifting percentages of hereditary background could be done by following some form of marriage regulation.[47] His lack of concern with breeding as a method perhaps explains why his view on how marriage selection should work always appeared so vague. Regardless of Galton's views, it is the objections raised by his listeners to his general approaches that make this document so significant. Their remarks show both that criticisms of the eugenics movement abounded and that a multitude of different strategies supported by early eugenicists had arisen by the early twentieth century. Such dissension greatly annoyed Galton. He closed the conference by saying the eugenic movement would accomplish nothing unless it formulated tactics "in a much better way than the majority of speakers seem to have done tonight."[48]

Reactions to Galton's Eugenic Views

The disapproval of Galton's theories that arose in the conference provide a good overview of the recurring criticisms of eugenics. These include criticisms of the basic genetic concepts and their definitions, criticisms of eugenicists' methodologies (aims, sampling, data collections, and analysis around statistical questions), criticisms from a sociological and political perspective, and finally criticisms of the very moral and ethical basis on which eugenic ideas were based.[49] Two critiques that are important for the argument of this article pinpoint the deviation between animal breeding and eugenics on the question of purity.

First, the differing aims of animal and human breeding were a core concern. H. G. Wells, a well-known British writer, addressed the issue of what "types" (in animal breeding terms, consistency) meant among humans. "So long as the consideration of types is not raised, the eugenic proposition is simple," Wells explained; "superior persons must mate with superior persons, inferior persons must not have any offspring at all, and the only thing needful is some test that will infallibly detect superiority." But are we to breed for one superior class or for many—and how would those types be defined? he asked, adding, "I must confess that much of Dr. Galton's classical work in this direction seems to be to be premature." Wells recognized that animal breeding, while promoting improvement in individuals, also promoted group uniformity and improvement. That type of uniformity in humans, he believed, was both undesirable and difficult to define.[50] Apparently Galton had lost sight of animal breeding's concern with consistency and uniformity of type. Other

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members of the panel were just as skeptical of Galton's approach as Wells, although for different reasons.[51]

The problem of type also attracted the attention of American scientists who were often supporters of the eugenic movement but more directly involved in agricultural breeding. O. F. Cook, a plant scientist for the USDA, serves as one example. He considered "type" to be at the heart of any breeding strategy regardless of the purebred emphasis on individual excellence. Cook pointed out a basic philosophical conflict between the aims of animal and plant breeding aims and those of eugenics. "The chief object of plant and animal breeders is to secure uniformity," he stated. "Viewed from this standpoint it is obvious that there is no agreement or even close analogy between breeding and eugenics." No one would want "the diversified human race" to become "a few unified varieties composed of duplicate individuals."[52] Cook basically argued that improvement in eugenics was not the same as improvement in plant or animal breeding because the idea of plant or animal uniformity could not be carried over to humans. Since uniformity was defined by agricultural breeders as purity, the ideology of purity within their framework could not be carried over to humans either. W. E. Castle, a eugenicist-leaning scholar at Harvard University (and an embryologist who turned to mammalian genetics after the rediscovery of Mendel's laws), did not agree. But while he suggested that, through positive eugenic breeding, greater improvement was possible, Castle did not directly address the underlying issue of types or the relationship of uniformity to purity.[53]

Sewall Wright, another American geneticist and student of Castle, also focused on the issue of type consistency in animal breeding, but not for reasons of applicability to eugenics. Wright's work, however, demonstrated how useful (and significant) Galton's fundamental biometric approach to breeding could be for purposes other than human improvement or purity breeding. Wright asked what animal breeding for consistency could tell him, not about eugenic breeding for improvement but rather about the process of evolution. Consistency meant inbreeding, and through inbreeding the establishment of new lines, but more important, it meant population bottlenecking, which might ultimately lead to new species. Inbreeding could, therefore, shift the genetic makeup of a constricted population, and in doing so it might offer clues into how the mechanics of evolution worked. Like Galton, Wright turned to the pedigree keeping of breeders in his research work. He assessed records of past breeding as applied particularly to Shorthorn cattle under the inbreeding strategies of Thomas Bates.[54] He explained, "It was apparent from my studies of the breeding history of Shorthorn cattle . . . that their improvement had actually

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occurred essentially by the shifting balance process rather than by mere mass selection. There were always many herds at any given time, but only a few were generally perceived as distinctly superior."[55] In other words, by inbreeding a small population of animals, one could in fact shift the genetic makeup of larger populations by breeding that inbred group into a more general population. The implications of this phenomenon were important to understanding the process of speciation. Wright also developed a way to quantify the effects of various inbreeding strategies.[56] Between 1915 and 1922, Wright devised a way of calculating the level of shared genes that would result from different inbreeding systems—brother to sister, first cousins, double first cousins, half brother to half sister, and so on.[57] These systems would lead directly to the theories of Jay Lush, a geneticist at Iowa State University, and subsequently to the rise of modern livestock (and quantitative) genetics.

The second major objection raised against Galton's proposals, which aroused considerable discussion in the 1904 talks, revolved around the issue of controlled marriages and related sociological, political, and ethical questions. State control of human affairs at that basic level proved to be unacceptable to most people, thereby overriding the importance of the purity question when it came to human breeding. One speaker, J. M. Robertson, noted: "It is vain to think to eliminate the factor of love or instinctive preference in marriage."[58] Another, "Mr. Hobhouse," believed that controlling marriages was ethical but would only be legislatively enforceable when the nature of heredity was clearly understood. For him, that evidently was not yet the case.[59] The idea of controlled marriage evoked ongoing negative reactions from the public and triggered particularly elegant remarks from English writer G. K. Chesterton. In the early 1920s, Chesterton wrote: "What is perfectly plain is this: that mankind have hitherto held the bond between man and woman so sacred, and the effect of it on children so incalculable, that they have always admired the maintenance of honour more than the maintenance of safety."[60] The planned mating of people with the object of breeding superior children was morally repulsive to him. The eugenic emphasis on planned marriages with future children in mind was also a complete reversal of traditional views of a man-woman relationship. People mated for love (or at least because of personal choice), which culminated in unknown children. Chesterton also identified the reasons why one effort at breeding for superior children practiced in New York State had failed. The Oneida community attempted planned breeding beginning in the 1840s. While the community changed the phenotype of its population to some extent, by 1881 directed breeding was discontinued because love between couples interfered with the strategy.[61]

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It was also evident from commentary by Galton's listeners that by 1904 the movement had become sharply divided into two distinct approaches. Galton's approach, positive eugenics (or breeding for improvement), appeared particularly objectionable to his audience. They found his positive aims nebulous, unenforceable (or impossible to regulate), and unethical. They seemed to recognize that Galton had not developed any concrete breeding methodology for a positive eugenic program. Some listeners were attracted to negative eugenics, the restriction of breeding within certain groups of people via strategies such as sterilization of the "unfit." H. G. Wells, for example, thought negative eugenics was more workable than the vague artificial-selection outlook of Galton. Wells argued, "It is in the sterilization of failures, and not in the selection of successes for breeding, that the possibility of an improvement of the human stock lies."[62] While negative eugenic strategies carried political issues and ethical concerns, it seemed to many people that such strategies were easier to navigate. As the well-known playwright George Bernard Shaw said, "It is worth pointing out that we never hesitate to carry out the negative side of eugenics with considerable zest, both on the scaffold and on the battlefield."[63] Regulation by government appeared relatively simple and straightforward. For a number of people, negative eugenics was more appealing than positive eugenics.

Scholars have identified a variety of explanations for why eugenics, in the face of such extensive criticisms, managed to reach any level of acceptability in the early twentieth century. The support from men like Pearson and Weldon of Galton's basic quantitative theories did not hurt. Another factor was the increasing level of government regulation over human affairs, coupled with an expanded institutional capacity for control.[64] But purebred breeding also played a role in the recognition of eugenics as a legitimate form of breeding. Until well into the twentieth century, purebred breeding was perceived by agricultural experts to be the most important type of practical improvement breeding for larger animals. This powerful and ongoing view that purebred breeding was the acceptable way to breed animals influenced attitudes toward eugenics.

A great deal of purebred breeding's credibility, especially over the late nineteenth and early twentieth centuries, rested on the illusion that purebred breeding was simply the modernization of Bakewell's Enlightenment breeding, which since the eighteenth century had been accepted as a scientific approach to the "art" of breeding. The influence of Thoroughbred horse breeding culture on purebred breeding had been mostly forgotten. Darwin was the first prominent person to mistakenly see purebred breeding simply as Bakewell's system,

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with no input from Thoroughbred culture. Increasingly, purebred breeders also ceased to recognize that Bates's breeding system was not synonymous with Enlightenment breeding or that the infiltration of Thoroughbred horse culture to farm breeding had created an entirely new, and more importantly non-Enlightenment, method.[65] The active support of purebred breeding, not only by agricultural experts but governments as well, echoed and encouraged that enduring belief. Public pedigree keeping and the pursuit of purity, aspects of Thoroughbred culture, had not been part of Bakewell's system. They were, however, critical in the functioning of purebred breeding.

Throughout this period (1883–1920), eugenicists remained primarily concerned with using pedigrees as a means of improving humans through some sort of selective process. The shared concern with pedigree keeping led eugenicists to see the animal breeding system as a logical model to follow. The perception that eugenicists were working under the mentorship of animal breeders led to an association between purebred breeding's cultural ideas about purity with eugenic breeding, even though the basis for purity in animal breeding—namely, inbreeding and marketability—could not migrate to eugenics. The fact that Galton and his fellow eugenicists had made no effort to understand these broader implications of purity within the purebred breeding methodology did not help to clarify the situation.[66] Pedigree use in animal breeding (inbreeding, consistency, and marketability) in fact had little in common with the projected and actual use of pedigrees in eugenics (evidence of inheritance via statistical quantification). Over time, however, quantification via pedigrees was superseded by the ideology of purity in the public mind. Purity became the eugenic definition of improvement. Under these conditions purity's meaning became vague and detached from its meaning in animal breeding. The rise of genetics after 1900 did little to change the situation. The new science did not undermine the faith that purebred breeding offered the only scientific way to breed. The failure of genetics to weaken the validity of purebred breeding encouraged not only the dominance of the system but also the acceptance of eugenics as a legitimate science for human improvement. In this fashion, purity itself became a force to be reckoned with. Various strategies of eugenics would develop over the early twentieth century, designed to bring about human improvement through systems devoted to "purity."[67]

Purity and Science: The Rise of Mendelism

The rediscovery of Mendel's laws in 1900 played into this evolving animal breeding-eugenic relationship. Under Mendelian theory, inheritance worked

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in a dominant and recessive way, and therefore characteristics not overtly evident in an individual might be present in that creature's makeup. Pedigrees could not account for recessive inheritance with any precision. Although it might seem that a reconsideration of pedigrees and purity was in order, for animal breeders there did not seem to be any obvious way of utilizing the information. Some experienced breeders even questioned what made Mendelian notions of heredity novel. For example, H. H. Stoddard, an American chicken breeder and journalist, argued Mendelism generally was nothing more than practical breeding under a different guise. "Mendelism, or the new genetics, or whatever it may be called," Stoddard noted, "offers at its present stage no new practical instructions for mating and breeding either the lower animals or humans. The professors who say that the old rule of 'breeding the best to the best,' is no good; turn right around and prescribe methods that amount to the same thing."[68] But Stoddard also believed that Mendelism was ultimately significant and would in the future offer practical breeders aid. He concluded, "The whole problem offered by Mendel's discovery, one of the most important as well as wonderful, in the annals of science, is such a complicated one that it will take generations to solve it, and at present the breeders of domestic animals . . . can derive little benefit or none at all from all that Mendelism can offer—in its present stage of development."[69] Even for scientists, it remained difficult to see how genetics could affect agricultural breeding of animals. W. E. Castle, for one, believed Mendelism offered the livestock breeder little guidance in new ways of practicing selection. He contended that as far as animal breeding was concerned (especially the larger animals), traditional methods would prevail. Farmers "breed animals as our fathers and grandfathers did because their time-honored methods succeed and we know of no reason for changing these methods," he wrote in a 1912 issue of *American Breeders' Magazine*.[70]

A good example of lengthy and thoughtful purebred breeder reaction to early Mendelism can be found in English Collie dog breeder William Mason's series of articles in his *Collie Folio*. Mason wrote extensively about Mendelism and purity in pedigrees between 1908 and 1912 and questioned the very meaning of purity. What Mendelism offered in terms of changing selection patterns, however, remained a mystery. In a 1908 article about Mendelism, he explained, "The whole conception of what is meant by a pure breed has been altered. . . . The new knowledge will enable the scientific grower to get a pure stock by crossing with stocks once thought impure, and this gives to the new variety at any time that it may be required all the strength of the mongrel without the least impairing its pure character."[71] In 1911 he took up

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the story again, noting, "Although a pedigree animal is, broadly speaking, of greater value than one minus this adjunct, the new knowledge all tends to show us that undue importance may easily be attached to the possession of a string of names of this nature."[72] In 1912 Mason continued to assess the implications of Mendelism in relation to hereditary purity, writing, "The term 'purity' as pursued by breeders receives new significance in the light of Mendel's discoveries. It used to be thought that 'pure' stock was only obtained after generations of unions of like to like that, in fact, the longer the pedigree the purer the race. Yet now we see that length of pedigree has very little to do with the matter."[73] Things may not be what we thought they were, Mason implied, but it was not clear what changes to make.

Pedigrees, however, denoted levels of inbreeding, and since inbreeding played a role in defining and evaluating purity for breeders, part of the historic linkage of pedigrees with purity remained intact after the advent of Mendelism. Purity likewise retained its importance in the marketplace. In fact, purity meant (and even defined) marketability, as far as breeders were concerned, and still does today. For example, in the Arabian horse industry, purity-pedigree trade patterns, prevalent since the 1830s, still dominate even in the face of advanced genetics and extensive evidence of flawed or inaccurately kept pedigrees. Accepted pedigrees define purity, and these in turn direct market value.[74] Bates's system, which entangled purity, pedigree, and market structure, turned out to be a powerful and enduring system. This entanglement does much to explain why the system's adherence to purity remained so strong and why purebred breeding appeared to be so impervious to science. Pedigrees remained fundamental. The power of pedigree over market value and trade guaranteed their continued significance, and purity was simply redefined to make it fit that reality.

The effects of Mendelism on eugenics were also relatively minor. Galton, for example, did not even mention the new science in his final remarks at the 1904 convention. He focused instead on biometry, his quantitative approach to heredity.[75] Even though Mendelism, with its orientation toward what would soon be described as gene units, appeared to offer little information on how pedigrees showed generational change, early eugenicists did not necessarily see a conflict between following a Mendelian or biometrical point of view when it came to using the pedigree tool to study hereditary input. In Britain, pedigrees were used after 1900 and until roughly 1930 by both Mendelian and biometric eugenicists. As one scholar put it, "Pedigrees were felt to give the raw facts of heredity . . . free of all more or less contentious interpretations" that had erupted in the biometric-Mendelian debate.[76]

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In other words, many believed that pedigrees still revealed the basic dynamics of inheritance. In the United States, eugenicists tended to emphasize pedigree research from a Mendelian, not a biometric, perspective. A good early example of heavily Mendelian-oriented pedigree research by an American eugenicist can be found in the work of Charles Davenport. In 1902, Davenport began with biometric experiments in animal and plant breeding but became a confirmed Mendelian and eugenicist. With financial support, Davenport stablished the Eugenics Records Office in 1910 at Cold Springs Harbor to collect pedigrees of families, cataloging traits in thousands of individuals. The continued reliance of eugenicists on pedigrees carried with it an ongoing attachment to purity as the definition of improvement.

The underlying theories behind biometry and Mendelism, which played a complicated role in the development of the science of genetics, therefore had no effect on eugenic research methodology: pedigrees, with their implications for purity, continued to be the basic tool.[77] In theory, eugenicists in the United States and Britain might support and even teach either biometry or Mendelism, but in practice they all relied only on pedigree research.[78] Since the variation between a Mendelian or biometric outlook did not undermine an ongoing emphasis on pedigree research, faith in the workability of Galton's ancestral law toward improvement (or purification) also continued. Animal breeding and eugenics, therefore, appeared to remain closely aligned because of their use of pedigrees. This was true even when pedigree research concentrated on negative eugenics. There were substantial differences, however. In negative eugenics, pedigrees were employed to find the inferior or "impure," not the superior or "pure," genes in order to remove them from the breeding pool. The removal from humanity of the "impure," by enforced restrictive breeding (sterilization), increasingly took center stage. This shift widened the gap between animal breeding and eugenics. The question of what role inbreeding might play in eugenic "purity" ideology widened the gap even further.

Purity in Breeding as a Pervasive Social Value

What, then, does this genealogy of purity in eugenics and animal breeding say about the broader social acceptance of notions of genetic purity? Is it possible, as historian Gabriel Rosenberg has suggested, that both animal breeding and eugenics merely absorbed the overarching values of early twentieth-century society?[79] The evidence suggests that only a vocal minority of scientists and breeders were devoted to purity ideology.

In North America, for example, where the purity concept was strongest, pre-1920 statistics about animal purchasing do not reveal such a trend.[80]

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Specific examples abound. Calculations by the Ontario government in 1919, for instance, revealed how little purity counted. Scrub, or nonpurebred bulls, accounted for as much as 75 to 80 percent of sales.[81] In the United States only two million of the nearly sixty-seven million head of cattle in 1920 were purebred.[82] Apparently the vast number of farmers were not buying purebred stock.

It is worth looking at the broader implications of these numbers. Reviewing the commentary of the majority of animal breeders provides a completely different picture from the one presented by the North American advocates of purebred breeding (purebred breeders, agricultural experts, and government officials). This commentary provides a broader context to the animal-eugenic purity story as well as how the purity vision fit with general society, although understanding it is not a straightforward project. General-farmer opinions are rarely obvious. Ideas about "blood," class, purity, physical excellence, and more were always generated by purebred breeders, agricultural experts, or the government. These people had a powerful voice in livestock affairs, and dominated the agricultural press, but their views represented what only a minority of animal breeders believed. Although general breeders were mostly silent on these subjects, when a specific issue threatened their breeding programs they clearly expressed their contrary views on purebred breeding and purity. Under these conditions surprisingly rich material emerges.

Such was the case when proposed legislation to enforce the use of purebred stallions arose in many American states and most Canadian provinces over the late nineteenth and early twentieth centuries. Material generated in agricultural documents and the press on horse breeding, state control over stud stallions, and the rise of purebred marketing cartels offers valuable information on what general breeders thought about "purity." As a group they did not support either purebred breeding or the ideology of purity. The higher cost of purebred stock, relative to crossbreds, certainly played a role in their opposition, but there were important intellectual differences as well. For example, general breeders did not see the linkage between quality, purity, and pedigree in the same way as purebred-breeder advocates. General breeders understood the process of heredity itself differently (and in many ways more correctly). It was not uncommon for horse breeders owning grade or crossbreds to adhere to Bakewell's Enlightenment (and later quantitative genetic) theory. They believed in the value of the progeny test and the significance of females in breeding, unlike purebred breeders, who tended to rely on ancestry breeding via pedigrees and to prioritize males. Grade owners argued that the selection of a breeding stallion should be done based on the quality of his

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foals and that it was equally important to use good mares.[83] Ordinary horse breeders had clear opinions regarding breeding methodology, views on state interference in breeding decisions, and attitudes toward heredity itself and the role of experience in the ability to breed properly, as well as conflicting convictions concerning the meaning of quality. As one American stallion owner put it: "Stallion owners are not, as a rule, fools" and had no interest in promoting the concerns of purebred breeders.[84]

The Ontario situation between 1906 and 1914 provides particularly rich commentary from general breeders. With respect to poor mares, for example, one breeder asked: "What do you expect, apples off a thorn tree, or cranberries from a gooseberry bush?" He added that purebred breeders placed too much emphasis on success in the show system: prize-winning stallions were not always good breeders.[85] Another argued that some purebreds should be described as scrubs, while some grades should not be thought of as being scrubs.[86] Another breeder stated that he would not hesitate to use a grade. A different stallion owner added that his crossbred was "as good a horse as ever was collared" and could trot thirty-six miles and outwork his neighbor's pair of purebreds. "Do not tie [our] hands," he said; "I do not think it is right." Others backed up this point of view. One breeder declared that no man could tell him how to breed. Another asserted there were a lot of poor purebreds around.[87] General breeders rejected purity as a meaningful characteristic and understood that purebred breeding was about markets, not quality. Their views on the nature of heredity, on how to breed properly, and on wider social attitudes to purebred breeding did not match those of the purebred advocates.

It seems from all the above that only a minority of the North American animal breeding world clung to purity breeding. That minority, however, was powerful and vocal. It is obvious why purebred breeders belonged to that small group: purity was part of the purebred breeding structure, primarily for marketing reasons. The voices of purebred breeders were amplified by support outside their ranks. Powerful actors adhered to the same view and were prepared to campaign for the spread of purebred genetics. The constant bombardment by agricultural experts and government officials, however, failed to bring about the desired results. Purity and purebred breeding never commanded widespread adherence in the broader North American breeding public, despite the considerable publicity generated by their ideas. The experts operated in a bubble, a bubble that only burst with the advent of quantitative genetics and artificial insemination technology after 1950. The connection between pedigree, purity, and quality was no longer credible.

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A brief review of the British situation shows less overall support for purity breeding. Purity (and even pedigrees) for animals had never taken on the same importance in Britain as in the United States and Canada. Purebred animals from Britain required certification of purity for entrance into North America, so British breeders complied with the North American purity obsession primarily for marketing reasons.[88] A good example of that trend can be seen in Scottish Clydesdale breeding. Inspired by the hot market for purebred Shorthorns in the transatlantic trade, tenant farmers Lawrence Drew and David Riddell set out to label the Clyde as a "breed" and not a "type." They believed that distinction would enable them to market horses better. While they claimed purity because they kept pedigrees in a stud book, they bred as they had in the past by crossing Shires on Clydes.[89] In response to the American accusation that he purchased English mares and sold their foals as pure Clydes, Drew responded, "I never in my life misrepresented the pedigree of any animal I sold. . . . The fusion of English blood has greatly improved the Clydesdale horse, and I recommend my friends [in North America] not to be led away with clap-trap about stud books."[90] Drew suggested that Americans should turn their attention to what quality was demonstrated in pedigrees. General breeders in Britain were even less enamored with purity breeding than the exporting breeders, a situation that worried the government because of the potential for damage to the export trade. Ordinary horsemen felt considerable pressure to change their ways.[91] The breeding scene in Britain provides even weaker evidence of support for purity in animal breeding than was the case in North America.

Animal breeding's historic relationship with eugenics is complicated and multifaceted. Understanding the role played by purity played in the development of either has become more important because of new scholarly work on eugenics and animal breeding. The parallel development theory, while a decided improvement over the older, more simplistic cause-and-effect approach, leaves many questions unanswered. This article assesses pedigree use (and purity within that framework) for both animal breeders and eugenicists. By looking at historic animal breeding methodology in relation to the rise of eugenic theory, it is possible to see how attitudes toward purity developed in each. It is evident, for example, that Galton was not drawn to the study of purebred animal breeding solely because of an interest in purity ideology. It was the use of pedigrees as data that commanded most of his attention. The use of purebred breeding concepts in eugenics, through Galton's assessment of pedigrees, seemed to heighten the value of purity as a new definition of improvement. This article also reveals that purity ideology was not widespread among general breeders,

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not even in North America where it appeared to be especially strong. Purity ideology commanded the interest of only a minority of the breeding world.

There were fundamental deviations between animal breeding and eugenics in the use of purity and pedigrees. Animal breeders, unlike eugenicists, found it relatively easy to define specific aims to drive breeding programs designed to promote purity. For eugenicists, vague notions of nobility or class type offered no clear avenue as to how selective breeding via planned mating would work. The association of inbreeding with purity in animal breeding was also difficult to transfer to eugenics. Inbreeding had become so strongly valued in animal breeding that purity could almost be defined as inbreeding. In contrast, eugenicists tended to see inbreeding as a sign of degeneration, and "purification" strategies applied to humans were not based on theories of inbreeding. Finally, purity's linkage with market value had no equivalent in any form of eugenics. It is true that early eugenicists believed that genetic improvement would lead to increased national wealth, but direct marketing and trade in humans was not part of their vision. The chief affinity that eugenics would have with animal breeding rested on the involvement of government through regulation, a complex story beyond the scope of this article, involving the extended power of the state over all walks of life. Fed by faith that science underlay both disciplines, governments in various countries supported eugenic strategies such as sterilization at the same time that they sought to control some forms of animal breeding through such legislation as stallion enrollment and licensing. Yet purebred breeders never wanted government interference in their breeding programs. Government may have applied pressure, but nowhere was control of breeding supported.

The mistaken view that purity lay at the bottom of both animal breeding and eugenics has caused considerable confusion. The assumption of a common notion of purity masks what made the ideology important to breeders—namely, the desire for improvement. The tendency to define improvement as purity has compounded the problem of differentiating what either concept meant in an animal breeding or eugenic context. This confusion has been amplified in some ways by the post-1960s erosion of the human-animal distinction, which emerged alongside advances in genetics and helped create an assumption that animal breeding had not made or led to eugenics but had always been a form of eugenics. The bogeyman "eugenics" is very much with us, because a number of human activities designed to bring about biological improvement still reflect embedded problems of ethics and power control. Purity still haunts us because of its apparently unbreakable, if elusive, association with improvement.

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Notes

1. See Paul, Stenhouse, and Spencer, *Eugenics at the Edges of Empire*.

2. See, for example, Wilmot, "Breeding Farm Animals and Humans"; Alexander, "Eugenics and Animal Science."

3. Max Planck Institute for the History of Science, *Conference*, 2–3.

4. See Bedford, "'Like Produces Like,'" 20, 40, 46, 59, 94. Bedford notes that farm groups in Alberta were active supporters of eugenic programs, indicating that animal and plant breeders might support eugenic principles. That did not mean, however, that they saw their work with plants and animals as linked with eugenics.

5. Rosenberg, "No Scrubs," 383.

6. For example, Darwin explained to Harvard University botanist Asa Gray in 1857, "All my notion about *how* species change are derived from long-continued study of the works of (and converse with) agriculturalists and horticulturists." Darwin suggested that the process of breeding in domestic animals and plants had been critical to developing his theory regarding natural selection. Charles Darwin to Asa Gray, July 20, 1857, Darwin Correspondence Project, University of Cambridge, www.darwinproject.ac.uk/entry-2125.

7. *Third Report of the Royal Commission on Horse Breeding*, vol. 27 of Reports of Commissioners, House of Commons, Parliament, 1890, 21, 27, 31, 41.

8. Charles Darwin, *Variation of Animals and Plants under Domestication*, 1:447.

9. Darwin, *On the Origin of Species*, 13.

10. It has been assumed for centuries that the Eastern breed behind the sire line of the Thoroughbred was the Arabian. While the validity of this idea—almost a cult—would be challenged many times on the basis of historical—but not biological—evidence, nothing really could be proven. (A recent assessment of the cult is Bibby, "Arabians in the Architecture.") Biological evidence, in the form of DNA studies on the Y chromosome of modern Thoroughbreds, has made it clear in recent years that the Turkoman, not the Arabian, went into the sire line of the Thoroughbred. See Wallner et al., "Y Chromosome"; Landry, "Disappearance of the Turk."

11. Much has been written about the breeding of the Thoroughbred horse. In particular, for more on historic views regarding the development of the Thoroughbred, see Allison, *British Thoroughbred Horse*. For an early attempt to apply genetics to an understanding of the Thoroughbred's hereditary background, see Cunningham, "Genetics." For more on how Thoroughbred breeders have rely on pedigree research in modern times see, Cassidy, *Sport of Kings*; Cassidy, *Horse People*. Of great importance is Mitchell, *Racehorse Breeding Theories*.

12. Orel and Wood, "Early Development in Artificial Selection," 151; Russell, *Like Engend'ring Like*, 104; Wood and Orel, *Genetic Prehistory in Selective Breeding*, 72.

13. See Sanders, *Short-Horn Cattle*, 14, 31, 34–35, 37–39, 44, 75, 81–85; Wright, "Measurement of Inbreeding and Relationship"; Cadwallander, *Thomas Bates and the Kirklevington Shorthorns*.

14. Sanders, *Short-Horn Cattle*, 69, 80.

15. Plumb, "Felix Renick, Pioneer," 21–22, 28–30, 35–41.

16. *Breeder's Gazette*, February 12, 1885, 239.

17. For more detail on this subject, see Derry, *Horses in Society*, 75–86; Derry, *Made to Order*, 82–86.

18. *Poultry Journal*, August 1910, 976–77. See also Felch, *Poultry Culture*.

19. A particularly clear description of Felch's inbreeding strategies and his chart appeared in an agricultural circular published in 1911 in Alberta. Alberta Department of Agriculture, *Practical Poultry Keeping*, 73.

20. *American Poultry Journal*, August 1911, 1268.

21. Felch, *Breeding and Management of Poultry*, 47.

22. An example of such chart reprinting can be seen in *Poultry Journal*, November 1908, 736. See also *Poultry Journal*, November 1906, 910.

23. Mitchell, *Racehorse Breeding Theories*, 273–306, 191–236; Tesio, *In His Own Words*; Cassidy, *Horse People*, 37–53.

24. For an example of his early work on heredity, see Galton, "Theory of Heredity," 329–48.

25. See, for example, Galton, "Hereditary Colour in Horses," 598–99.

26. See, Gillham, *Triumph of the Pedigree*, for more on that critical linkage between pedigrees and eugenics.

27. Galton, "Average Contribution of Each Several Ancestor," 402, 403.

28. Galton, "Average Contribution of Each Several Ancestor," 408.

29. Derry, Lightman, and Ankey, review of *The Invention of the Modern Dog*, 84.

30. Worboys, Strange, and Pemberton, *Invention of the Modern Dog*, 169.

31. For an extensive review of what could be described as the black box approach of breeders to the laws of heredity see Derry, "Theory and Method," 324–61; and the first section of Derry, *Made to Order*.

32. Galton, "Average Contribution of Each Several Ancestor," 408.

33. See, for example, his remarks on Thoroughbred horse breeding in Galton, "Appendix G," 12–15.

34. William Housman, "'Compositing' Photographs," *Live Stock Journal*, September 30, 1898, 425. Housman, *Improved Shorthorn*.

35. Francis Galton, "Photographic Records of Pedigree Stock," *Live Stock Journal*, October 7, 1898, 455.

36. See Galton, "Examination into the Registered Speeds," 379–87.

37. Oleson and Voss, *Organization of Knowledge in America*, 219–28.

38. "Eugenics on the Farm."

39. For more on Galton's law, see Froggatt and Nevin, "Galton's 'Law of Ancestral Heredity'"; Bulmer, "Galton's Law of Ancestral Heredity"; Gillham, "Evolution by Jumps"; Froggatt and Nevin, "'Law of Ancestral Heredity' and the Mendelian-Ancestrian Controversy."

40. Gillham, *Life of Sir Francis Galton*, 9.

41. Gillham, *Life of Sir Francis Galton*, 9; Hill, *Quantitative Genetics*, 9, 10. For examples of Pearson's work on the subject, see Pearson, "On the Systematic Fitting of Curves," especially pt. 1, 266.

42. In its first issue, Galton stated, "The primary object of Biometry is to afford material that shall be exact enough for the discovery of incipient changes in evolution which are too small to be otherwise apparent." Bulmer, *Francis Galton*, 299.

43. Galton, "Possible Improvement of the Human Breed," 663.

44. In 1905 Galton delved into the problem of controlling marriages, and even into what marriage types might mean. Most of his arguments, however, were nebulous, with little useful material on how to orchestrate marriage controls. Galton, "Studies in Eugenics," 11–20.

45. Galton, "Possible Improvement of the Human Breed," 665.

46. Galton, "Eugenics," 3.

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47. Galton, "Eugenics," 1–6.
48. Galton, "Eugenics," 24–25.
49. Allen, "Eugenics and Modern Biology," 314–25.
50. H. G. Wells, response in Galton, "Eugenics," 11.
51. Warner, response in Galton, "Eugenics," 11–12.
52. Cook, "Eugenics and Breeding," 30.
53. See Castle, "Laws of Heredity of Galton and Mendel."
54. See Wright, "Measurement of Inbreeding and Relationship"; Wright, "Duchess Family of Shorthorns."
55. Wright, "Relationship of Livestock Breeding to Theories of Evolution."
56. See Crow, "Sewall Wright's Place in Twentieth-Century Biology," 58, 62–66.
57. Provine, *Sewall Wright and Evolutionary Biology*, 156.
58. John M. Robertson, response in Galton, "Eugenics," 23.
59. Hobhouse, response in Galton, "Eugenics," 16.
60. See Chesterton, *Eugenics and Other Evils*, 7–8.
61. See Olin, "Oneida Community."
62. H. G. Wells, response in Galton, "Eugenics," 11.
63. George Bernard Shaw, response in Galton, "Eugenics," 21.
64. This is one of the main points made by Mazumdar in *Eugenics, Human Genetics, and Human Failings*.
65. See, for example, *Farmer's Advocate*, January 1876, 13; *Farmer's Advocate*, February 1876, 27; *Farmer's Advocate*, March 1876, 46; *Farmer's Advocate*, December 8, 1910, 1927–28; *Farming World and Canadian Farm and Home*, January 1, 1906, 161. See Sessional Paper 13, Legislature of Ontario, 1875–1876, 31–32; Sessional Paper 12, Legislature of Ontario, 1877, 48.
66. Michael Bulmer's excellent book *Francis Galton* makes it clear that Galton was primarily interested in how heredity worked and from an evolutionary point of view. Breeding methodology as such was not a primary interest.
67. A few sources to start with, when studying eugenics, are Kevles, *In the Name of Eugenics*; Mazumdar, *Eugenics, Human Genetics, and Human Failings*; Stern, *Eugenic Nation*; Kühl, *For the Betterment of the Race*; Ladd-Taylor, *Fixing the Poor*.
68. *Poultry Journal*, October 1913, 1278. In 1906 William Bateson coined the word *genetics*. This situation allied Mendelism primarily with genetics and encouraged the further marginalization of biometry from mainline hereditary science.
69. *Poultry Journal*, October 1913, 1278.
70. *American Breeders' Magazine* 3, 1912, 271. See also Castle, *Heredity in Relation to Evolution and Animal Breeding*; Castle, "Pure Lines and Selection," 93–97.
71. William Mason, "Mendel's Theory," *Collie Folio*, January 1908, 21–22.
72. William Mason, "The Elusive Breeding Problem—Pedigree," *Collie Folio*, September 1911, 308.
73. William Mason, "The Elusive Breeding Problem—Purity," *Collie Folio*, June 1912, 207.
74. For more on purity, breeding, and markets, see Derry, *Made to Order*, 127–75.
75. Galton, "Eugenics," 24–25.
76. Mazumdar, *Eugenics, Human Genetics, and Human Failings*, 58.
77. See the chapter "The Age of Pedigrees" in Mazumdar, *Eugenics, Human Genetics, and Human Failings*, 58–95.
78. Mazumdar, *Eugenics, Human Genetics, and Human Failings*, 87.
79. Rosenberg, "No Scrubs," 386–87.
80. Brown, *Report on the Herds and Flocks*, 30.
81. *Canada Agricultural Gazette*, 1919, 659.

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82. United States Census for Agriculture, 1930. See table 46, p. 602; table 62, p. 618.

83. Sessional Paper 65, Legislature of Ontario, 1907, "Special Investigation on Horse Breeding in Ontario, 1906," 20, 23, 36, 39.

84. *Breeder's Gazette*, April 18, 1888, 394–95. For more on stallion legislation in the United States, see Derry, *Horses in Society*, chap. 9.

85. *Farmer's Advocate*, January 22, 1914, 132. For more on the Canadian situation see Derry, *Horses in Society*.

86. *Farmer's Advocate*, January 29, 1914, 175, 176.

87. Sessional Paper 22, Legislature of Ontario, 1909, 180–84.

88. See Derry, *Horses in Society*; Derry, *Made to Order*; Derry, "Transition from Type to Breed."

89. Baird, *Clydesdale Horse*, 20–21, 26, 27–30.

90. *Breeder's Gazette*, August 10, 1882, 213.

91. See discussions in "Minutes of Evidence Taken Before the Departmental Committee Appointed to Enquire and Report as the British Trade in Live Stock with the Colonies and Other Countries," 1912, Cd. 6032. See also Wilmot, "From 'Public Service' to Artificial Insemination."

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