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Heredity – The Production of an Epistemic Space

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1. GENERATION AND HEREDITY

Biological heredity is the transmission of characters and dispositions in organic reproduction. From today's perspective it appears to be of such paramount importance for the make-up of individual organisms and of such immediate and eye-catching evidence that it is hard to even imagine that there were times in which it did not occupy the centre of the life sciences. Yet until the end of the eighteenth century not only the concept of heredity but the very concept of reproduction was absent from speculations about living beings, as François Jacob remarked in his book *La logique du vivant* (1970):

> Only towards the end of the eighteenth century did the word and the concept of reproduction make their appearance to describe the formation of living beings. Until that time, living beings did not reproduce; they were engendered. [...]. The generation of every plant and every animal was, to some degree, a unique, isolated event, independent of any other creation, rather like the production of a work of art by man.[1]

There is a claim implicit to Jacob's judgment that has been confirmed by other historians of biology time and again: Before the end of the eighteenth century and, according to some historians, even until the advent of Mendelism hereditary transmission was not a domain regarded as separate from the contingencies of conception, pregnancy, embryonic development, parturition, and even lactation.[2] Similarity between progenitors and their descendants was thought to come about simply as a result of the similarity in the constellation of causal factors involved in each act of generation. It is in this sense that William Harvey, in his *Anatomical Exercises on the Generation of Animals* (1651), could maintain that the "work of the father and mother is to be discerned both in the body and mental character of the offspring, and in all else that follows or accompanies temperament",[3] while he simultaneously held the view that both "the male and female [are] merely the efficient instruments [of generation], subservient in all respects to the Supreme Creator, or father of all things."[4] As he went on immediately, taking up a thought of the "the great leader in philosophy", Aristotle: "In this sense, consequently, it is well said that the sun and moon engender man; because, with the advent and secession of the sun, come spring

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1 (Jacob 1993), 19-20. For a more detailed account of the development of a discourse of reproduction in the eighteenth century see (Jordanova 1995).
2 (Lesky 1950), 5; (Russell 1986), 40; (Allen 1986); (Bowler 1989), 6; Lefèvre, this volume.
3 (Harvey 1847), 363.
4 Ibid, 367.

and autumn, seasons which mostly correspond with the generation and decay of animated beings."[5] Inherited, connate, and acquired properties of organisms, the organic processes of transmission, embryonic development, and adaptation, in short: nature and nurture, heredity and environment – in the sense that these dichotomies should acquire with the end of the nineteenth century – were not distinguished in Early Modern notions of generation.

The stories about monstrous births due to astral influences and maternal imagination that convey this Early Modern perspective have often been retold, mostly as witnessing the Early Modern interest in the preter- and supernatural.[6] We would like to add another one illustrating that it was perfectly possible to assume this perspective in the thoroughly naturalistic framework of the late eighteenth century as well. Lawrence Sterne's novel *The Life and Opinions of Tristram Shandy, Gentleman* (1760) begins with the episode of its unhappy hero's conception: Tristram Shandy's father had the habit to fulfill his marital obligations on the eve of the first Sunday each month, and always after having drawn up the big clock in the hallway. One of these Sundays, while Tristram Shandy was right about to be conceived, his mother interfered with the usual routine by exclaiming: "Pray, my dear, have you not forgot to wind up the clock." The bewilderment and distraction that resulted for her husband with that insensible question in a very crucial moment, was the bad start for the entirely unhappy life of Tristram Shandy. As the latter retrospectively reasons at the beginning of the novel:

> I wish either my father or my mother, or indeed both of them, as they were in duty both equally bound to it, had minded what they were about when they begot me; had they duly consider'd how much depended upon what they were then doing; – that not only the production of a rational Being was con- cern'd in it, but that possibly the happy formation and temperature of his body, perhaps his genius and the very cast of his mind; – and, for aught they knew to the contrary, even the fortunes of his whole house might take their turn from the humours and dispositions which were then uppermost [...] .[7]

The concept of organic production that comes to the fore in this example, leaves no room for anything substantial to be said beyond the singular event of procreation, understood as an individual, separate act with its unique constellation of causes and effects, like drawing up a clock, as it were. Accordingly, it were metaphors of alchemy and art, including the mechanical arts, which governed the discourse of generation in the seventeenth and eighteenth centuries, as Jacob well observed.[8] René Descartes, e.g., described the ini-

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5 Ibid.; Harvey is quoting Aristotle *De gen. et corr.* 336a32-b2; on Harvey's theory of generation with regard to this dependence on Aristotle see (Gregory 2001).

6 (Pinto-Correia 1997), ch. 3 and 4; (Daston and Park 1998); cf. De Renzi, this volume, on maternal imagination.

7 (Sterne 1760), 1.

8 (Jacob 1993), 24-25.

tial formation of the fetus as a process, in which the male semen "is fermented and cooked together by maternal heat, its parts entering a subtler mixture."[9]

In contrast to this, metaphors of heredity – so common nowadays and, in their original legal as well as in their secondary biological domain of application referring to a rich register of intergenerational rules and taxonomies – only began to gain currency in the first half of the nineteenth century. To be sure: Phenomena that nowadays would count as expressions of organic inheritance – as the recurrence of distinctive traits in the second generation, or the running of physical or mental peculiarities along familial lines, both on the paternal and maternal side – had by no means gone unnoticed prior to the end of the eighteenth century. It seems, however, to be a simple matter of historical fact that these phenomena were not addressed using metaphors of heredity (except in the narrow, but highly significant field of hereditary diseases).[10]

Far from regarding the late advent of hereditary metaphors in the early nineteenth century as the result of a mere linguistic shift, we take it as an indication for an antecedent *longue durée* process, in the course of which the reproduction of organic beings, including human beings, gradually became articulated in such a way that it was recognizable as a domain distinct from other biological domains and governed by laws of its own. In its original context, the legal one, heredity concerns the distribution of property along a structure outlined by a set of rules and taxonomies that specify the conditions under which property may be passed on, upon the death of the proprietor, from one person to the other or, to put it more generally, from one generation to the next. The subsequent metaphorical application of heredity to processes of organic reproduction therefore presupposes that organic reproduction itself becomes conceivable empirically as a temporal process defined by a structure. And this again depends on practices through which organisms (including humans) are related materially in space and time, be it actively by experiment, be it passively by keeping records of such relations. Heredity, one might say, results from the attempt to gain control over the flow of time through the construction of an (ideally) atemporal structure.[11]

In an essay entitled "A Theory of Heredity", which was published in 1876 and which can very well be called the founding document of modern hereditary thought,[12] Francis Galton came back to the idea again and again that biological heredity – extending over generations and generations of ancestors and descendants, physically connected only through the product of sexual interaction, i.e. the fertilized egg – could only be understood, if it was reduced to a structure, a spatial structure more spefically. He suggested to call this space – which he identified with the "newly fertilized ovum" filled with the "germs or gemmules or whatever they may be called" from which the body develops subsequently

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9 (Descartes 1996), 507.
10 (Rey 1989), 7; (López Beltrán 2004).
11 Cf. (Gayon 1995).
12 On Galton's importance for the modern theory of heredity see (Olby 1985), 55-63; (Gayon 1998), 105-106.

– "stirp" (derived from *stirpes*, Latin for "root"),[13]. Among other things, he compared it to a "post office", where mailbags full of letters are emptied to be redistributed to their recipients,[14] and to a "nation", of whose members only some become elected to serve as "representatives" in the fully developed body. These were not, as Galton stressed, "idle metaphors, but strict analogies [...] worthy of being pursued, as they give a much needed clearness to views on heredity."[15]

Galton's remark that the spatial terms he used in speaking about heredity were not "idle metaphors, but strict analogies" is significant for its realist undertones. Before the metaphor of biological heredity could be applied at all, phenomena of organic reproduction had to be reconfigured discursively as to make reproduction itself accessible as a phenomenon that extended beyond the production of individual beings. Observations of and reflections on the individual generative act were clearly not enough to forge conceptions of biological heredity, not to speak of conceptions of a "space" of heredity as the one Galton had in mind (and which nowadays, as it were, is crammed with microscopic entities like chromosomes or DNA molecules). Genealogies had to be constructed, distinctions to be drawn, connections to be made *among individual beings* to produce the epistemic space that biological heredity came to occupy. Galton's reflections on heredity, and the strangely awkward spatial metaphors he chose to describe it, point to the immense complexity of the problem: Not only the genealogical "space", i.e. ancesto-descendent relations extending over at least three generations, had to be explored for presumed regularities; the same space also had to be conceived of as being represented somehow in a "space not exceeding the size of the head of a pin," i.e. the cytological space "of the newly fertilized ovum", [16] as this only provided the physical connection between ancestors and their descendents.

The common theme of this book is to explore the various cultural settings, in which the processes took place historically that converged upon the constitution of the epistemic space that Galton was addressing with his theory of heredity. In contrast to Jacob, who in a Foucauldian fashion portrayed the passage from generation to heredity as a succession of epistemes separated by sharp epistemological breaks, the step-wise and distributed, often highly contingent and heterogeneous nature of this historical process will be stressed. In this introductory chapter, we will try to draw a concise picture of this *longue durée* development, by summarizing the findings of the individual contributions that are to follow, but also by adding our own interpretation to these findings – an interpretation that will not necessarily be the expression of a perfect consensus among the authors of this collective volume. In a first section we will try to delineate the chronological and thematic scope of this book in more detail. In a second section we will then sharpen the contours of the historiographical problem that this scope entails, namely to account for the development of a concept while it was still in flux and not yet given a fixed and definite

13 (Galton 1876), 330
14 Ibid., 331.
15 Ibid., 336.
16 Ibid., 330.

general meaning. Finally, in summarizing the individual results of the present volume, we will try to outline the major historical developments responsible for the evolution of the discourse of heredity.

1. The Distribution of Early Modern Heredity

There exist a number of histories of genetics written from the perspective of a history of ideas. François Jacob's *La logique du vivant* (1970; engl. transl. 1973), Robert Olby's *Origins of Mendelism* (1966, 2nd ed. 1985), and Peter Bowler's *The Mendelian Revolution* (1989) have set lasting standards in this respect. There are also some elaborate, far from whiggish histories written from a disciplinary perspective, like Hans Stubbe's *Kurze Geschichte der Genetik* (1963; engl. transl. 1972), Leslie Clarence Dunn's *A short history of genetics* (1965), and Elof Axel Carlson's *The gene: a critical history* (1966), though it is revealing that the latter two let their histories begin with the twentieth century only. More recent publications on historical and systematic aspects of central notions in genetics are the collective volume *The Concept of the Gene in Development and Evolution* (2000), edited by Peter Beurton, Raphael Falk, and Hans-Jörg Rheinberger, Evelyn Fox Keller's *The Century of the Gene* (2000), and Lenny Moss's *What Genes Can't Do* (2003). As the aforementioned books, they review the history of the gene concept largely from an epistemological perspective. Despite numerous valuable case studies, what is missing so far is a comprehensive volume that embraces the cultural history of heredity by presenting the emerging knowledge of heredity in its broader practical and historical contexts, both in a wider synchronical and diachronical perspective.

This state of affairs betrays the extent to which heredity has become entrenched as a fundamental notion of twentieth century biology, either creating the illusion that heredity must have been recognized as such since times immemorial or that there was no heredity to talk of before the advent of genetics. The volume "The Production of Heredity" wants to counteract both illusions and to close the respective research lacunas that have resulted from them with respect to the early history of hereditary thought in the life sciences. It forms the first part in a planned series of three volumes that will cover this history from the early modern period to the present. As the first volume in this series, "The Production of Heredity" extends over the period in which heredity, formerly a concept restricted to the realm of law, began to be applied as a metaphor in matters of organic reproduction and successively became a concept of central importance to the life and human sciences. We identify the beginning of this period with the emergence of racial classifications in early sixteenth-century Spain and Portugal, and its end with the appearance of general biological theories of heredity (like Charles Darwin's theory of pangenesis or Francis Galton's theory of the "stirp") in the second third of the nineteenth century.

This chronological bracket is by no means supposed to mark sharp breaks or to reflect a linear development between its bounds. It rather belongs to the fundamental theses of this volume that concepts of heredity initially developed in widely different forms and in-

dependently in various domains like medicine, natural history, or breeding, and that the merging of these domains into a general theory of heredity in mid-nineteenth century biology was a historically contingent process whose (pre)-history needs to be unfolded in all its entanglements. As we already noticed: as an empirical phenomenon, the recurrence of characters over generations, including some of the more complex patterns involved, had not gone unnoticed in the early modern period, nor had it in antiquity or the middle ages.[17] However, this recognition of intergenerational similarities remained in a distributed and scattered state, effectively inhibiting the formation of a generalized notion of heredity that could bind these domains together.[18]

The first thing to be noted about this distribution is a fundamental asymmetry: While the biological notion of heredity, in retrospect, appears to have been a surprisingly late achievement, inheritance and its regulation began to form a hotly debated focus of legal and political discourses much earlier. According to a well known thesis by historical anthropologist Jack Goody, it was primarily the church, with its dependence on donations from individuals, that began in the early medieval period to interfere with traditional "strategies of heirship" – as adoption, cousin marriage, concubinage, marriage with affines (relatives by marriage), or the remarriage of divorced persons – to bring about an alienation of family holdings.[19] The Gregorian reforms of the 11th century in particular achieved this aim by instituting celibacy and by prohibiting marriage between kin up to the seventh degree. In this, kinship was defined according to the much more inclusive Germanic system, which calculated kinship degree among relatives by counting the number of generations back to the first common ancestor, rather than the number of generative acts that lay between relatives, as in the Roman system (see fig. 1), and was even further extended by including both cognates (i. e. relatives by blood) and affines under these calculations. The emerging territorial state, competing with, but also similar to the Church in its "bureaucratic and property-holding forms," readily stepped in to add its force to these regulations.[20] By the end of the seventeenth century these had become extended and enforced to such a degree that any alliance between families was effectively subject to dispensations from the church and/or the state.[21]

The result of these developments was, on the one hand, a veritable outburst of genealogical activities, witnessing a fundamental innovation with the introduction of the *ipse* or *ego* – representing an individual rather than the sibling group or *truncus*, that had been at the center of earlier genealogical representations – as the departing point for kinship calculations in genealogical tables and diagrams.[22] On the other hand, noble families in par-

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17 For overviews see (Lesky 1950), (Stubbe 1965), ch. 1-3, and the preprints from results of a conference on heredity in the middle ages organized by Maaike van der Luugt and Charles de Miramon at http://www.ehess.fr/centres/gas/article.php3?id_article=31.

18 Terrall, this volume; Lefèvre, this volume.

19 (Goody 1976), 123.

20 Ibid., 136-144.

21 (Sabean 1998), ch. 3.

22 (Goody 1976), 142-146; on the forms and political functions of early modern genealogy see (Heck 2002).

ticular tried to counteract the dispersion of family property by preferring the agnatic, i. e. male descendent line (the medieval *lignage*) at the expense of other collateral kin in the transmission of property, office, or title.[23] This may account for the curious fact that, as far as we can see, the aristocratic discourse of "noble blood" played a surprisingly small role in the emergent discourse of biological heredity in the early nineteenth century, although data on such features as the "Habsburg lip" or hemophilia in noble families were readily employed. In fact, the point in emphasizing the noble lineage, often with a privilege accorded to the first-born son, was to exclude "blood" relatives (later born sons, daughters, matrilineal kin) from heirship to avoid the dispersal of (mainly landed) property.

Ironically, these strategies only led to a further emphasis on the individual and a further erosion of the "natural" rights of kin-groups. Moreover, they came under increasing attack in the eighteenth century for their obvious injustice, culminating in one of the French revolution's central claims, namely that no generation should force its regulations upon future generations.[24] The *Code civile*, consequently, contains inheritance regulations based on equal rights among individual heirs and full divisibility of property according to a mathematical formula that was based on an analysis of kinship degrees.[25] Though primogeniture was partly reinstated during the nineteenth century, it had come under lasting pressure. As a result, the early nineteenth century saw a resurfacing of marriage to close kin, preferably cousin marriages, to hold together family property in transmission and to establish close familial networks of mutual trust and loyalty to cope with capitalist conditions of wealth and property.[26] The Darwin and Wedgewood families provide a formidable example for these strategies, including the concurrent fears of degeneration.[27]

Without claiming any expert knowledge on these extremely complex and regionally diverse developments, we have tried to give an account of some of the major ones, to derive an important point: Outside the discourse of the life sciences there did exist a well developed, lively, and controversial discourse on heredity that incorporated a wealth of definitions, taxonomies, calculation procedures, and arguments. And yet, as we already stated, it remains a fact that these rich semantics were not taken up and deployed, neither by natural historians nor by natural philosophers, to account for what we nowadays would readily identify as hereditary phenomena. Even the naturalistic justifications, that sometimes found their way into the legal and political discourse – as the justification of the subsumption of affines under incest regulations by the "unity of flesh and blood" supposedly instituted by marriage,[28] or the denunciation of primogeniture as "monstruous" by

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23 Ibid., 120-123.
24 Vedder, this volume.
25 (*Napoleons Gesetzbuch.* 1808), 312-323, 346-367.
26 Sabean, this volume.
27 (Browne 2002), ch. 8.
28 (Sabean 1998), 70-71.

French revolutionaries[29] – were not immediately reflected in medical or philosophic accounts on generation, as far as we can see.

It is nevertheless possible to identify a decisive trend for biological heredity *avant la lettre*. There were several, highly specific, and altogether separate knowledge domains, which indeed became increasingly structured during the early modern period by the *de facto* recognition of hereditary transmission of differential characters. These include: 1) the recruitment of hybridization experiments and family histories to probe the role of the sexes and the validity of preformation theories in late seventeenth and eighteenth century debates about generation;[30] 2) natural history, botany in particular, where, from the late seventeenth century on, the definition of specific differences increasingly relied upon their "constancy" from generation to generation;[31] 3) animal and plant breeding, which began to hybridize and "mould" organisms for specific, distinctive features from about mid-eighteenth century on;[32] 4) anthropology, which began to study physical difference, notably skin colour, and its physiological and historical origins to account for human diversity;[33] and 5) the classification of diseases as hereditary in nosography, which had a tradition dating back to antiquity, but became increasingly a focus of medical theorizing during the eighteenth century.[34]

While this distribution of hereditary knowledge over separate domains once again shows, that hereditary phenomena in the realm of the life sciences had not really gone unnoticed before the end of the eighteenth century, it also evinces what did not exist: a general concept of heredity underlying these domains. Such a general concept of heredity was only slowly to emerge in the second third of the nineteenth century, with a first culmination in the works of Prosper Lucas, Charles Darwin, and Francis Galton. Carlos López Beltrán has illustrated this transition by pointing out a decisive linguistic shift: While the use of the adjective hereditary can be dated back, as already mentioned, to antiquity in the context of nosography (*maladies héréditaires*), a transition to a nominal use (*hérédité*) took place only from the 1830s onwards, first among French physiologists and physicians, then in other European scientific communities. This shift indicates a reification of the concept, or, in López Beltrán's words, the establishment of a "structured set of meanings that outlined and unified an emerging biological conceptual space [...] produc[ing] the first appearance of our modern concept of biological heredity." [35] It also implies a concomitant shift, namely the erosion of a set of very ancient distinctions drawn with respect to observed similarities between parents and offspring. Discussions of such similarities do, once again, witness a *de facto* recognition of phenomena that we today would call hereditary. But they were classified according to categories which the modern notion of heredity

29 Vedder, this volume.
30 (Roger 1993), 81-91; (Rey 1989); Terrall, this volume.
31 Müller-Wille, this volume.
32 (Roberts 1929); (Zirkle 1935); (Russell 1986); Ratcliff, this volume; Wood, this volume.
33 (Braude 1997); Mazzolini, this volume.
34 (Olby 1993); López Beltrán, this volume.
35 (López Beltrán 2003).

systematically cuts across: A distinction was made between specific vs. individual, paternal vs. maternal, ancestral vs. parental, normal vs. pathological similarities, and even between similarities pertaining to the left and the right body half.[36] All these distinctions gave way to a generalized notion of heredity gravitating around relations among traits or dispositions independent of the particular life forms they were part of, whether pathological or normal, maternal or paternal, individual or specific.

This leaves us with three major developments under the period that this volume is dedicated to, and that we will try to relate and explain in the remainder of this introduction: a relatively early obsession with questions of heredity in the legal and political sphere, an erosion of traditional distinctions of intergenerational similarities alongside this emergence, and a relatively late emergence of heredity in biological discourse. Relating these developments to each other involves a specific historiographical problem, namely to give an explanatory account of the evolution of a knowledge regime while it still lacks a common linguistic, conceptual and institutional framework. We will try to address this problem in the next section.

2. Heredity as a Knowledge Regime

The perspective that "The Production of Heredity" takes is neither one of a conventional history of ideas nor one of a mere social history. The volume will rather explore the emergence of specific practices, the shaping of standards and taxonomies, the evolution of architectures of hereditary knowledge, and the eventual conjunction of these diverse factors as they occurred in a variety of social arenas. "Heredity", according to this perspective, is more than and quite different from what came to be regarded and respected as the scientific discipline "genetics". The volume is less about the history, or even pre-history, of a scientific concept, theory, or discipline, than about the history of the production of a broader knowledge regime, in which a naturalistic conception of heredity took shape that today affects all domains of society.[37]

Centering on the history of a knowledge regime, rather than on the history of a concept or theory, has two main consequences. First, "heredity" needs not to be treated as a notion with a fixed and given meaning to begin with. We have become acquainted with a conception of heredity that expresses the permanence of form over generations, not necessarily leading, but nevertheless lending itself to naturalistic justifications of political authority and cultural conservatism.[38] Instead of either acknowledging or criticizing such anachronistic reifications, heredity will be treated throughout this volume as a notion that gradually assumed an internal structure in terms of changing classifications and shifting

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36 See (Lesky 1950); (Stubbe 1965), ch. 1-3; (Rey 1989).

37 With "knowledge regime" we are adopting a term that Dominique Pestre introduced to avoid the problems that the more narrow, and historically highly variable connotations of "science" create for any attempt at writing a *longue durée* history of modern science; see (Pestre 2003), 31-37.

38 See, e.g., (Jordanova 1995), 375.

perceptions of causalities. It makes a difference, e.g., if inheritance of individual characteristics on the one hand and specific forms on the other are held separate, or if they are conflated; whether heredity is considered as "soft" and thus to some extent reversible, or "hard" and thus as irreversible. We will also see how these structures vary over time and only eventually acquire an internal dynamics of disciplinary power that was organized around a core concept of heredity.

Second, and in consequence, the dynamics that hereditary knowledge exhibits in these respects will be explored with regard to its dependence on the practices and institutions in which it became implemented. Acclimatization experiments in the eighteenth century, e.g., were used to distinguish constant, species-specific characters from characters varying individually with external conditions like climate and soil. However, this very practice also resulted in setting the stage for identifying characters that were peculiar to certain individuals within a species only and yet remained constant even under varying external conditions.[39] This is an instance of a feature that is to be observed repeatedly in the history of the efforts of making sense of hereditary phenomena: The experimental realization of a generally accepted conceptual dichotomy with regard to heredity leads, in the very process of its institutional implementation, to its dissolution and to the delineation of phenomena that are in need of alternative descriptions and explanations. The taxonomies and causalities subsumed under biological heredity, if put into practice and institutionalized, furnish the very conditions for contrary evidence and the resolution of the ensuing conceptual challenges.

A beautiful illustration of these points is provided by the system of "*las castas*" that was introduced in Spanish and Portuguese America in the sixteenth century already. This anthropological classification scheme originated from attempts to find a measure by which loyalty towards the crown as well as legal and social status could be allocated to the various sections of colonial society. It was primarily based on a classification of these sections according to skin color, to a lesser degree also on hair form and eye color. Children resulting from mixed marriages were positioned in this scheme in analogy to the simple mechanism of color mixing, implying "blending" as the causal relation connecting (traits of) parents with (traits of) their offspring. As Buffon put it with respect to this system (quoting Corneilles Pauws *Recherches philosophiques sur les Américains*, 1770-1771): "D'un mulâtre et de la Négresse vient le quarteron, qui a trois quarts de noir et un quart de blanc."[40] The system of *castas* was frequently visualized in pictures arranged in tabular form (see fig. 2), each of them showing a mixed couple and its child, and each bearing an inscription that states the components entering the mixture (each parent's *casta*) and its result (the child's *casta*).

Despite its rigid appearance, the *castas* system remained in constant flux throughout the early modern period, as witnessed by a rich proliferation of *castas* terms. And yet, it

39 Müller-Wille, this volume.
40 (Buffon 1971), 352.

was not despite, but just because it was so rigidly based on an abstract classification according to color and on blending or mixture as an equally abstract causal relation, that the *castas* scheme could cope with this proliferation. The distinction according to three colors – white, black, and brown – that lay at the basis of the system defined the positions for all sorts of intermediate and more complicated cases. And the basic mechanism of mixture offered a unified explanation for their coming about, as it can be regarded as operating independently of the particular circumstances under which it takes place. Thus it was because of its analytic and quasi-mechanical character, that this system could absorb a wealth of new phenomena while remaining stable in its basic outlines. The fact that the classification according to *castas* was not only a mere *Gedankenspiel*, but an institution that accorded legal status to the members of a society in permanent flux (reflected in the depiction of the *castas* in their legally sanctioned costumes and occupations, "hooked," as it were, onto the underlying mechanism), demonstrates that it indeed provides one of the first instances for the transferal of legal conceptions of heredity to the realm of biological reproduction.[41]

Clearly occupying a position at the intersection of the epistemic, political, and cultural, in fact, organizing that very intersection, the *castas* system furnishes a palpable example for an element of the knowledge regime of heredity. It clearly meets two minimal conditions that allow us to speak about it as hereditary knowledge at all: The transmission of physical properties from one generation to the other forms a limited and autonomous domain of discourse (having its counterpart in a "genre" with regard to its visualization in paintings); and it exhibits a certain inner structure in terms of a taxonomy and a set of propositions about the causal relationships connecting the entities posited in this taxonomy.[42] The idiosyncratic and highly localized origin of the *castas* system shows, moreover, that it is a matter of degree from whereon it is legitimate to speak of particular instances of a discourse of heredity.[43] Thus it is also possible, for instance, to regard the discussions about the recurrence of individual characteristics in the second generation, apparently transmitted from grandparent to grandchild, that scatter texts on generation since antiquity as elements of a nascent knowledge regime of biological heredity – although it is hardly possible to speak about them as instances of a full-fledged theory of heredity, as they were only weakly developed both in terms of contextual delimitation and inner conceptual structure.[44] The same holds true for the discourse on hereditary diseases, which seems to have persisted, as already mentioned, throughout the history of medicine.

The attention paid to heredity as a knowledge regime is the reason why the essays in this volume follow each other neither in an historical nor in a thematic order. Instead a

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41 (Diggs 1953); Mazzolini, this volume.

42 In a sense, we are adopting these minimal conditions from Mary Hesse's network approach to theories (see (Hesse 1974), ch. 1 and 2), without, however, wanting to restrict ourselves to theoretical knowledge, nor buying into the holistic assumptions that underlie Hesse's approach.

43 The *castas* system, though intricate, was certainly a product of folklore rather than science, and was not meant, at its origin, to serve as a universal racial theory; see (Canizares Esguerra 1999) on this.

44 Cf. Terrall, this volume.

structure was chosen according to the cultural domains – law, medicine, natural history, breeding, physiological and biological theories, anthropology – in which different phenomena came to be conceptualized in terms of heredity. These domains were subsequently modified, partially conjoined, and finally integrated to form the domain of a generalized concept of biological heredity. Throughout the period here considered, however, this concept was largely implicit and remained in constant flux and contest. It may be indicative for this conceptual flux that until the middle of the nineteenth century several, but only scattered and very tentative attempts were made at developing registration forms and representational schemes through which basic variables of heredity could be visualized and handled in terms of data collection, data display, and data processing. We have mentioned one example already, the depictions of Latin American *castas*. Marc Ratcliff gives us another example, from the late eighteenth century, of an attempt at a genealogical order that tries to combine genealogical information both in terms of varietal descent and in terms of hybridization events to account for the emergence of different sorts of strawberry. Laure Cartron shows that medical notions of heredity in early nineteenth century France took shape and were at the same time backed by statistical tables and the keeping of marriage registers that in turn became tools for the management of populations in the broader context of a hygienic regime of individual and collective health improvement. Breeders started to keep logbooks that allowed to track the selective production of progeny both up to parental and down to filial generations, as Roger Wood and Paul White exemplify in their reports on sheep breeding practices around the turn to the nineteenth century in Moravia and cart horse breeding in Victorian England, respectively.

Thus we see spring up a variety of symbolic means recruited for measuring out the barely charted grounds of hereditary phenomena at the end of the period considered in this volume. The hardening out of such inscription and registration procedures will be a topic to be pursued in detail in the coming volumes. It is certainly not too early, however, to maintain in this volume already, that the development of these inscription technologies, which clearly bear the sign of their origin in the excessive genealogical chartings that played such a prominent role in early modern legal and political arenas, was a necessary condition for the full development of the epistemic space that Francis Galton wanted to adress in his essay “A Theory of Heredity”. It remains, however, to be seen why, in the first place, they were taken up at all from these arenas and transferred to the domain of scientific inquiries into generation, which, after all, had been able for two thousand years to do without them.

3. The Genesis of Biological Heredity

The central historiographical problem of the present volume can be put like this: How is it possible that the phenomenon of hereditary transmission, which, from a contemporary perspective, appears to be of such an importance and seems to be so tangible in its effects was subjected to systematic conceptualization so late? The answer that emerges from the

articles that are to follow may come as a surprise. From them it is evident that the concept of heredity did by no means emerge from a growing attention to regularities of character transmission, a sort of fixation of the scientific mind on the laws of nature at the expense of the contingencies and complexities of "real life," another triumph of the execution of the scientific method. As a matter of fact, such attention had been around since antiquity with respect to organisms, and largely so without giving rise to a discourse of heredity. The example of the Latin American *castas* system that we presented in the last section demonstrates that the contexts that gave rise to a knowledge of heredity were much more specific. It indicates that the emergence of heredity as a research attractor, as a discursive center, occurred in a knowledge regime that started to unfold *when people, objects, and relationships among them were set into motion*.

To put our thesis differently: The problem that heredity came to address was not the constancy of species, but the patterns and processes that structure life on the intra-specific level, and this shift of attention was the result of a mobilization of early modern life at different levels. Mobilizing plants and animals, for example, was a precondition for being able at all to distinguish between inherited and environmentally induced traits in organisms. Only when organisms were actually removed from their natural and (agri-)cultural habitats could environmental differences manifest themselves in trait differences and heritable traits manifest their steadiness against a background of environmental change. Breeding new varieties for specific marketable characteristics, the exchange of specimens among botanical and zoological gardens, experiments in fertilization and hybridization of geographically separated plants and animals, the dislocation of Europeans and Africans that accompanied colonialism, and the appearance of new social strata in the context of industrialisation and urbanisation, all these processes interlocked in relaxing and severing cultural and natural ties and thus provided the material substrate for the emerging discourse of heredity.

It is a truism, of course, that the principle of "like engenders like" had been around since the earliest times of Greek poetry and philosophy, as an expression for what ought to happen as a rule.[45] This "law" remained unanalyzed, however: It lacked the kind of inner structure that could have provoked the productive application of a metaphor which, in its proper context, that of legal regulations of property transmission, possessed such complex semantics as "heredity" did. And as Wolfgang Lefèvre demonstrates for the cases of Lamarck and Geoffroy St. Hilaire in this volume, this remained valid up to the early nineteenth century for both preformationist and epigenetic theories of evolution. In a sense, even, both preformation and epigenesis – and both conceptions have a well-known, ancient legacy – excluded heredity, at least in their extreme forms, preexistence and occasionalist theories: according to the doctrine of preexistence, where preformation precedes any generation, nothing is transmitted in generation because everything has been there from the beginning; according to occasionalism, where any generation depends on the in-

45 (Stubbe 1965), 10-12.

terference of creative powers (divine or vital ones), nothing is transmitted in generation because in each instant everything is created from scratch.

As Peter McLaughlin points out in his contribution, it is in Immanuel Kant that we encounter a theory of propagation which is neither preformationist nor epigenetic – and in which, at the same time, conceptions of heredity began to unfold a manifold of specific meanings. "Anerben," "ererben," "vererben," "forterben" are all terms that Kant used in this context to distinguish, as McLaughlin puts it, "various aspects, permutations and combinations of hereditary phenomena." The phenomenon that gave rise to this proliferation of terms was no longer simply the similarity in kind that offspring exhibit with regard to their parents. It was rather a narrowly circumscribed, highly specific phenomenon, namely the existence of distinct races in the human species distinguished by traits that blended in hybrids, but were invariably transmitted to offspring even under changed, environmental conditions. Empirically this peculiar behaviour was exhibited to Kant by Portuguese colonists in Africa (whose children remained white, despite dislocation) and black Africans transported to Europe (who likewise continued to produce black children). Such a phenomenon undercut the ancient distinction of specific forms and individual peculiarities: characterizing classes at a subspecific level, racial characters belonged to the individual peculiarities that interfered with the universality of species form; yet being infallibly reproduced generation by generation they seemed to be subject to the same regularities that governed species form. To account for this, Kant brought together natural law and contingent (family) history in his concept of *Vererbung*: the potential or *Anlagen* for hereditary traits were included from the very beginning in the original organisation of ancestors – thus, in a sense, being not "acquired" at all; but once they had been expressed as actual traits in reaction to a change in environment – now, in a sense, indeed being "acquired" – they were permanently and irrevocably transmitted.

The way in which Kant set up the problem and the way in which he advanced a solution by exploring the complex semantics of *Vererbung* can be regarded as prototypical for the emergence of biological heredity. The problem was not the constancy of species forms but the patterns of variety that structure life at a sub-specific level. As long as such patterns tended to coincide with the confinement of organisms to locally circumscribed environments, they were readily explained by the permanence of ties between living beings and their "natural places." In these cases, it is, in a sense, the place that "inherits" its inhabitants and impresses its character upon them – as generally indicated by the passages we quoted from Harvey's *Anatomical Exercises on the Generation of Animals* in the beginning, and as more specifically indicated by early modern instances in which the passing on of familial diseases was compared to the passing on of land.[46] It is only when these ties were dissolved in favor of a variety of relationships between forms, places, and modes of trans-

[46] See, e.g., the quote from Jean Fernal with which Carlos López Beltrán opens his contribution to this volume.

mission that a need arose for a complex metaphor like heredity to be inserted in order to account for the proliferating phenomena.

The motivation to apply and explore the concept of heredity in face of a mobilization of social and natural ties through transplantations and hybrid unions can be observed in all the cultural sub-fields that are explored in the contributions to this volume. Yes, from what we learn from the first section of this volume about discussions of inheritance regulations in legal and political arenas, it seems to be the increasing importance of mobile over landed property in the first place that brought heredity to the fore as a hotly debated legal problem. According to David Sabean it were the "new conditions of a capitalist economy [that] changed the ways families related to property." Instead of being organized "around what one can conceptualize as 'stable' properties," "families created far flung networks, exchanging children for education, as service personnel, and eventually as managers and owners of firms" and thus "thrust the weight of family dynamics towards alliance and affinity" rather than lineal descent. In consequence, as Ulrike Vedder shows in her contribution, patriarchal authority, entails and primogeniture regulations, the status of the illegitimate born, the values of real estate and the abstracting power of money in inheritance became foci of intense conflict. One way in which such conflicts tended to be resolved – of particular interest to our volume's topic, the genesis of biological heredity – is highlighted by Silvia de Renzi in her contribution on the seventeenth century legal physician Paolo Zacchia: Faced with an increasing number of paternity disputes in court rooms, Zacchia turned to "nature" – more specifically "temperament" as an "internal resemblance" manifested by resemblances in habits or diseases – as a "stable and reliable source of evidence." Relying on the conviction that nature acts regularly and consistently in all its productions, including those that for one reason or other might appear illegitimate, this move could protect the patriarchal order as well as the rights of illegitimate children (protected by canonical law) in situations were both were being contested. Against the background of a continually increasing use of parish registers in court decisions, Zacchia's suggestion, though it initially failed to convince, was an attempt to ensure both the equality of individuals as well as the particularity of blood relations by "expanding the space occupied by the natural at the expense of both the preternatural and the supernatural", and it was for this reason that he turned to a fresh analysis of the nature of heredity.

"Temperament" or "diathesis," the constitutional disposition towards specific diseases, also formed the key concept of discussions among physicians about hereditary diseases in eighteenth and nineteenth century.[47] As Carlos López Beltrán stresses in his contribution to this volume, it was amongst physicians, more specifically French medical men and physiologists, that the noun "hérédité" was first adopted. Hereditary diseases had received growing attention throughout the eighteenth century, culminating in two prize competi-

[47] See (Olby 1993) for an overview that also encompasses the Hippocratic and Galenic tradtion, from which these concepts originated.

tions issued by the Royal Society for Medicine (Paris) at the end of the eighteenth century. As extensively discussed by López Beltrán, a set of distinctions – e.g. between hereditary or congenital, connate and acquired diseases – , a set of observational criteria – e.g. homochrony, i. e. the same timing in the outbreak of hereditary diseases, and the occurrence of the same disease adopting familial patterns in different climatic or social circumstances – as well as a set of causal concepts – e.g. latency, which caused considerable problems for the two traditional medical frameworks, humoralism and solidism, as well as various conceptions of "soft", i.e. reversible, vs. "hard", i.e. irreversible heritability – were fleshed out, clarified, and sharpened in the process, predestining the noun "heredity" as "the carrier of a structured set of meanings that outlined and unified an emerging biological concept."

The reasons for these developments are as complex as the art of medicine has always been, but two of them stand out: First, hereditary diseases were instrumentalized in the political arena. As Gianna Pomata observed in a comment presented at one of our workshops: "A recurrent feature of the medical discourse on heredity in the eighteenth and early nineteenth century is the critique of the aristocratic family." [48] At the focus of interest in the eighteenth century, as Philip Wilson argues in his contribution on Erasmus Darwin, were mostly "noble" maladies like gout, the "patrician malady" *par excellence*, believed to be "softly" inherited by over-consumption. This focus shifted in the nineteenth century, after the aristocratic family model had declined, to "degenerative" diseases like phthisis (tuberculosis) and madness, ascribed to the rapidly growing class of landless and poor migrating to urban centers, and believed to be subject to "hard" heredity, as discussed in Laure Cartrons contribution. Now, to quote Pomata once again, "these classes, rather than the aristocracy, were perceived as a threat to the social order."[49]

The second set of reasons for the changes in medical views of hereditary diseases resides in the strong changes that the social role of the medical community underwent at the turn to the nineteenth century: The new scientistic profile that medical men sought, as Laure Cartron argues, made it advisable to define thoroughly where the art of medicine met its limits in incurable, constitutional, and thus heritable diseases.[50] New responsibilities of physicians for public hygiene, on the other hand, led to the definition of dangers – as heritable diseases – which lay hidden in the populace and which consequently only the expert could address. Finally, hospitalization and medical statistics, the latter depending on the former, made possible new forms of representation – medical topographies and chronicles – through which not only individual case or family histories, but the population in its entirety became visible. "Whereas before," as Cartron summarizes these changes," the administrative perspective sought information in order to ensure a reasonable management in a world considered as stable, now a rationalizing perspective replaced it, aimed at defining effective modes of action in an industrializing and increasingly complex

48 (Pomata 2003), 150.
49 Ibid.
50 See also (Waller 2003).

world." The genealogical and epidemiological data that accumulated as a consequence were certainly one of the most important prerequisites to disentangle the more complex patterns of familial diseases and to abstract them from diseases caused by local influences or differences in life style.

The role that the hospital, with its published and unpublished records, played for the constitution of the discourse of heredity in medicine, can be compared with the role that botanical gardens and menageries played for that discourse in natural history. We mentioned already that one of the necessary (though not sufficient) conditions to separate the environmental from the hereditary was that organisms were actually removed from their natural and (agri- as well as horti-)cultural environments. This was essentially what botanical gardens and menageries effected by accumulating living specimens from all over the world under a regime of technologically controlled conditions. The exchange of specimens among these institutions, to further enlarge collections, enhanced the possibilities to detect even more complex hereditary patterns, like atavism, segregation or mutation. It is therefore no wonder that gardens and menageries, though instituted originally for the descriptive purposes of natural history, also formed the original locus for the hybridization experiments, which, from the mid-eighteenth century on, constituted a research tradition that led right up to Mendel's famous experiments.[51] Similar experiments in transplantation and hybridization were carried out in the breeders' community, which became increasingly organized in professional societies in the course of the eighteenth century and exchanged their breeds over wide geographic areas, as described by Roger Wood. However, the intricate relationship between naturalists and breeders demonstrates also how strong the institutional obstacles remained until well into the nineteenth century for a unified view of heredity: In the Linnaean tradition horticultural varieties were not regarded as a proper subject for botanists, as Marc Ratcliff shows in his contribution, and it was only in the second third of the nineteenth century, as Wood reports, that naturalists were ready to adopt for their experiments the genealogical recording techniques that breeders had developed. The specific perspective of attending to individual traits in populations, that breeders had developed to "mould" their creatures for specific marketable traits, was particularly unintuitive to naturalists, who – with the notable exception of Gregor Mendel – would remain interested in the origin, permanence, and possible transformation of species rather than individual variants throughout the nineteenth century.[52]

The erosion of institutional barriers such as that between naturalists and breeders – reflected on the conceptual level in the distinction between an internally determined species form and externally determined varieties – or that between medical practitioners and natural scientists – reflected on the conceptual level in the distinction between the pathological and the normal – seems to have played an important role in paving the way for the

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51 (Olby 1985), ch. 1 and 2; (Larson 1994), ch. 3; Müller-Wille, this volume; see (Roberts 1929), ch. 1-3, and (Zirkle 1935) for detailed accounts of the history of hybridism.

52 (Olby 1979); (Bowler 1989), ch. 5.

discourse of heredity. In the long run, such erosions allowed for a unitary perspective under which both the specific and the individual, both normal and pathological, even monstrous life forms, in short: both regular and deviant forms would appear as determined by the same set of natural laws governing organic reproduction as such.[53] The "life of the species (*Gattungsleben*)", as we would like to put it by borrowing a term from the German naturalist Carl Friedrich Kielmeyer (1765-1844),[54] the vital processes connecting a multiplicity of life forms rather than the life of particular beings, became the subject of a new science that, famously, would receive its name of "biology" around 1800.

Both Michel Foucault and François Jacob have identified "organization" as the key concept constitutive of the "new" science of biology.[55] We do not want to question the importance of this conceptual innovation. But it seems pertinent to us for a full understanding of what constituted biology, to recognize the interindividual, intraspecific dimension that most of its concepts gained around 1800.[56] Instead of being conceived as functions of individual bodies, organic functions like generation, growth, development, nutrition, sensation became increasingly perceived as reproductive functions physically constituting the unity of species.[57] As George Louis Leclerc Comte de Buffon put it programmatically in his influential *Discourse on the Manner of Studying and Expounding Natural History* (1749): "The history [... of the species] ought to treat only relations, which the things of nature have among themselves and with us. The history of an animal ought to be not only the history of the individual, but that of the entire species."[58] Consequently, he maintained that it "is neither, [...] the number, nor the collection of similar individuals, but the constant succession and renovation of these individuals, which constitutes the species."[59]

The focus on organization that emerged around 1800 is only seemingly a paradoxical concomitant of the growing attention for the "life of the species". As a matter of fact, reproduction was at the very heart of Kant's influential concept of a "natural purpose (*Naturzweck*)" as a "thing [...] that is both cause and effect of itself", by which he tried to determine the causality specific to organized beings.[60] With regard to reproduction proper, i.e. the production of an organized being through another organized being of its kind, this point of view had to lead to a growing focus on the internal organization of the germ.

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53 (Canguilhem 1991), 29-46.
54 (Kielmeyer 1993), 5.
55 (Foucault 1966), 238-245; (Jacob 1993), ch. 2.
56 Cf. (Coleman 1971) for a portrait of nineteenth-century biology that misses this dimension, so that Coleman can, consequently, maintain that "well into the [nineteenth] century biology and physiology were virtually synonymous expressions."
57 Cf. (Ritterbush 1964), ch. 5; (Roger 1993), 567-582; (Jacob 1993), 88-92; (Lenoir 1982), ch. 1; (Larson 1994); (Spary 1996), ch. 3.
58 (Buffon 1749), 30; English translation quoted from (Lyon and Sloan 1981), 111. Similar views were held by Linnaeus; see (Müller-Wille 1999), 267-283. According to (Larson 1994) Buffon and Linnaeus, together with Albrecht and Haller, formed the "triumvirate" that outlined much of the research questions that should occupy naturalists and physiologists of the late eighteenth century. On Buffon's legacy specifically see (Sloan 1979).
59 (Buffon 1791), vol. 3, 404.
60 (Jacob 1993), 88-89; (MacLaughlin 1990), 44-51.

It is, after all, the germ only that provides the physical link in the reproduction of species. Two alternative (yet non-exclusive) frames of how to conceive of the germ's potency to bring forth beings of its own kind were formulated in the eighteenth century, and should persist side by side throughout the nineteenth century: The first one, paradigmatically formulated in Johann Friedrich Blumenbach concept of "vital force (*Bildungstrieb*)", conceived of heredity as a force acting, from generation to generation, at a distance, in analogy to Newtonian gravitation. The second, paradigmatically formulated in Buffon's concept of "organic molecules (*molecules organiques*)", saw heredity as residing in organized matter that was transmitted from one generation to the other.[61] The latter, "structuralist" paradigm is also exemplified in the growing prominence of solidist models of the causation of hereditary diseases in early nineteenth century medicine, as discussed by Carlos López Beltrán.

Thus we see heredity coming to be inserted precisely at the intersection of the life of the species and the life of the individual in the biology that began to take form around 1800. The institutions we mentioned before, botanical gardens, museums, breeder's societies, hospitals and medical administrations, were instrumental in gaining this specifically biological perspective, as we argued before. But they were certainly not sufficient to forge a concept of biological heredity. For the eighteenth and early nineteenth century, heredity largely remained, as López Beltrán puts it, "a descriptive metaphor in search for a causal substance." To effect more than this, additional conjunctions had to occur between what may be largely described as descriptive approaches in natural history and medical statistics on the one hand and experimental approaches in physiology and pathology on the other. It is, we believe, for the lack of such conjunctions that two fields in which one could have expected an early emergence of hereditary theories actually show a surprisingly late engagement with such theories: evolution and cytology. As Wolfgang Lefèvre argues in his contribution on the work of Jean-Baptiste Lamarck and Étienne Geoffroy St. Hilaire, these important evolutionary thinkers showed a conspicuous lack of concern with the question of hereditary transmission, and this despite of the fact that recent advances in biogeography and paleontology had already made both of them move from an assumption of "stable relations between organic forms and habitats" to "theories of adaptation to changing environmental conditions that opened a window for the question of heredity." Cell theorists of the first half of the nineteenth century like Theodor Schwann, on the other hand, seem to have been much more engaged with the problem of the representation of the whole organism in its (cellular) parts than with the possibility of "attribut[ing] reproductive and differentiating dispositions to inner structures of the cell nuclei", as François Duchesnaeu maintains in his contribution. With respect to the longstanding separation of natural history and physiology, a distinction made by the French physiologist Claude Bernard is par-

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[61] (Rheinberger and Müller-Wille in press); on Blumenbach's concept of "*Bildungstrieb*" see (Lenoir 1980) and (McLaughlin 1982), on Buffon's concept of "*moules intérieures*" see (Roger 1993), 542-558 and (Ibrahim 1987).

ticularly revealing. In his *Leçons sur les phénomens de la vie commune aux animaux et aux végétaux* (1878) Bernard distinguished between "chemical" and "morphological synthesis" in organisms: The former, "chemical synthesis", consisted in vital functions effected by physico-chemical processes, and was thus accessible to experimentation; the latter, "morphological" or "organizing synthesis", consisted in the concatenation and mutual subordination of such vital functions in the reproduction of organic forms, and eluded, at least in the eyes of Bernard, experimental intervention, a resort being provided by the assumption of "vital forces" only.[62] It is equally revealing for the role that the conjunction of naturalist and physiological concerns had for the emergence of heredity, that one of the earliest protagonists of a full-fledged theory of heredity, Charles Darwin, is known to have entertained a life-long, consistent interest in phenomena like the life of colonial organisms that allowed to extend analogies from entities above the level of the individual organism (species) to entities below that level (buds, cells, gemmules).[63]

This leads us to another arena in which the discourse on heredity took shape. As Mary Terrall forcefully argues, it were Enlightenment "discussions about the nature and organization of living matter," the attempts of eighteenth-century thinkers to "get below the surface to general laws of nature and life" and access to what Buffon called "the hidden means that nature might be employing for the generation of creatures" that discursively brought together many of the disparate elements of the knowledge regime of heredity described in the preceding paragraphs. The philosophical discourse, emancipating itself in the eighteenth century from theology, law, and medicine, certainly lacked control through experiment and the rigor of later theorizing in biology. But it was precisely because it was not yet "parsed by discipline or profession", as Terrall tells us, that philosophical discourse could easily transgress boundaries between knowledge domains, as, e.g. those between the practical knowledge of breeders and physiological speculation. Moreover, philosophical discourse invested its subjects with concerns that went far beyond scientific or artisanal specialities and were of fundamental political and theological significance. The debate about preformation in the eighteenth century, e.g., touched upon questions as to whether matter was wholly passive or endowed with active forces, whether the formation of individuals was subject to particular superordinate powers or whether individuals were autonomous and equal, and whether the sexes had equal parts in the generation of offspring.[64] The challenges to patriarchal order – with its privileges and particularities passed on in lineal descent – formulated by the Enlightenment, and epitomized in the French revolution, provide much of the background to the increasing tendency in the early nineteenth century to back the attribution of social and cultural status in a universal natural order defined by the distribution of hereditary dispositions.[65]

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62 (Rheinberger 1994).
63 (Hodge 1985).
64 (Roger 1993), epilogue; (Roe 1981).

It does not come as a surprise, therefore, that anthropology in particular became one of the "hot spots" of hereditary discourse. Clearly, this was a field that lacked direct access by experiment, the only substitute, though with its own irresolvable paradoxes, being the observation of "savage children", as discussed by Nicolas Pethes. The exponentially growing number of ethnographic reports from extra-European regions, however, opened a "veritable 'laboratory of human nature'" facilitating a "natural history of man" at the end of the eighteenth century.[66] A curious focus of the nascent discourse of physical anthropology was its preoccupation with skin-color, an external trait *par excellence*. In the Early Modern period, black skin-color had become identified with Africa and with lineal descent from one of the Son's of Noah, Ham.[67] By the end of the seventeenth century the focus shifted from such assertions of difference to the study of the anatomical and historical origin of that difference.[68] With respect to heredity, as Renato Mazzolini shows in this volume, it was the system of *castas* (discussed above already) in particular, which provided one of the earliest models for its conceptualization and "a vast field of , 'pre-Mendelian' investigation." Originating from a caste system in place in fifteenth-century Spain and Portugal, it evolved into a universal scheme of racial classification (as first put forward by Carl Linnaeus in his *Systema naturae*, 1735) that was supported by various theories accounting for the origin of differences within the human species by "degeneration" (as those of Buffon, Blumenbach, and Kant). Race, like the concept of caste, its correlate in cultural history, became a "bio-political" notion, i.e. a notion that resorted to the common nature of humans, their reproductive unity, not only to explain, but also to justify and even govern the uneven distribution of wealth, power, and opportunities among humans. The same holds true for the concept of "innateness" that crystallized around cases of "savage children" in the early nineteenth century (as discussed by Pethes), the Victorian ideology of the "self-made man" (as discussed by White), and, finally, the discourse on the origin of "genius", that culminated in Galton's book on "Hereditary Genius" (1869), an "exemplar of hereditary theory", as Stefan Willer sees it, because Galton anchored "the concept of genius [...] in a complex of predispositions or talents" verifiable by genealogical analysis. In all of these disparate arenas – forming parts of the literary rather than scientific discourse – the specific and the individual were conflated in elementary dispositions, temporarily manifesting themselves in individual bodies but omnipresent within the species. "[Original] work and genre, individual and species [were] one and the same, manifestations of a nature that freely represents itself in generic forms," as Helmut Müller-Sievers maintains in his epilogue to this volume.

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65 This is the sense in which Michel Foucault diagnosed a passage from a "principle of alliance" to a "dispositive of sexuality" around 1800 in the first volume of his "History of Sexuality" (Foucault 1993); see also (Foucault 1991).

66 (Sloan 1995), 114.

67 (Braude 1997).

68 (Mazzolini 1994).

CONCLUSION

The various domains of the knowledge regime of heredity that we have described in the previous section as giving rise, each in its own right, to a discourse of biological heredity were not brought together, after the model of "influence", by a unitary "idea" of heredity. Rather, conjunctions between them came about by a kind of domino effect that mobilization in one field had on another. The growth of a class that depended on mobile property evoked a culture of leisure collecting and breeding. The import of plants for collection purposes of natural history inspired attempts at their acclimatization for economic purposes (and vice versa). The breeder, with his successes in establishing marketable strains of plants and animals, provided the model for the "self-made man." This points less to a unitary "culture" or "episteme" of heredity that suddenly emerged around 1800, but rather to a piecemeal relaxation of social and natural ties in several, highly specific, and largely independent cultural sub-fields, which in their subsequent conjunction outlined the field of phenomena that eventually, in the mid-nineteenth century, came to be addressed by a concept of biological heredity. Before Darwin's and Galton's attempts in synthesizing this field, one may very well say, that hereditary thought in the life sciences was in a pre-paradigmatic stage in the Kuhnian sense, lacking both exemplary problem solutions and a disciplinary matrix that could define a more or less clear cut research program.

Although this makes it difficult, even impossible, to draw a general picture of the historical development that led to Darwin's and Galton's achievements, it is possible, in hindsight, to characterize the result of that development. As a point of departure we choose a quote from Darwin's *Variation of plants and animals under domestication* (1868), a quote that Galton almost certainly had in mind, when he praised his cousin's approach in *A theory of Heredity:*

> The fertilized germ of one of the higher animals, subjected as it is to so vast a series of changes from the germinal cell to old age – incessantly agitated by what Quatrefages well calls *tourbillon vital* – is perhaps the most wonderful object in nature. It is probable that hardly a change of any kind affects either parent, without some mark being left on the germ. But on the doctrine of reversion [i.e. the reappearance of heritable traits in the second generation], as given in this chapter the germ becomes a far more marvellous object, for, besides the visible changes which it undergoes, we must believe that it is crowded with invisible characters, proper to both sexes, to both the right and left side of the body, and to a long line of male and female ancestors separated by hundreds or even thousands of generations from the present time: and these characters, like those written on paper with invisible ink, lie ready to be evolved whenever the organization is disturbed by certain known or unknown conditions.[69]

[69] (Darwin 1988), 30-31.

Two aspects of Darwin's theory of heredity, evident from this passage, are highly remarkable when compared with William Harvey's view of organic reproduction that we discussed as exemplary for the Early Modern period at the beginning. First of all, it becomes obvious how far Darwin already endorsed a view of biological heredity that abstracted from personal relations between parents and their offspring. While clearly conceding the possibility of an inheritance of acquired properties, Darwin makes it clear beyond doubt, that the true carriers of the properties to be inherited are not the parents themselves, but submicroscopic entities – "invisible characters" – that circulate, from generation to generation, among individuals within one and the same species.[70] Secondly, and more fundamentally, the quoted passage evinces a peculiar inversion in comparison with early modern conceptions of organic productions: while the latter emphasize the vertical dimension of lineal descent – where parental organisms actually *make* their offspring – Darwin invokes an image where the lateral dimension dominates, the dimension of a common reservoir of dispositions, passed down from the sum total of ancestors, redistributed in each generation among individuals, and competing now, in the present, for their realization. We take these two aspects as the fundamental hallmarks of modern hereditary thought.

It would not be too far fetched to see analogies with two important aspects of capitalist economy in this: alienation and circulation.[71] We would like to emphasize something else, however. The complex constellation that Darwin invokes to describe "the most wonderful object in nature", the germ – thousands of generations represented virtually in the microscopic space of the fertilized egg – points to the complexity of the problem of heredity. One can take both Darwin's and Galton's attempts to characterize heredity as a "space" quite seriously and speak of an "epistemic space" of heredity that came into being in mid-nineteenth century. In contrast to other subjects of biological research, which can be called "epistemic things" in the sense of being determined within individual experimental settings, heredity depended on a vast, spatial configuration of distributed technologies and institutions connected by a system of exchange: botanical gardens, hospitals, chemical and physiological laboratories, genealogical and statistical archives.[72] Capitalism and bourgeois culture certainly facilitated the various conjunctions that made this configuration possible; but heredity as an epistemic space was neither a mere construction to justify, nor a mere ideological reflection. As we probably are only beginning to realize fully today, in times where genetic screening, testing, and patenting pervades all sectors of social and economic life, the epistemic space that biological heredity came to occupy resided in the heart of capitalist institutions from its very inception.

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70 This view was later canonized in the 1911 paper, in which Wilhelm Johannsen coined the terms phenotype and genotype ((Johannsen 1911)); see on this (Rheinberger and Müller-Wille in press).

71 On the inspiration that Darwin drew from Adam Smith's work see (Schweber 1977).

72 For an account of the Morgan school of *Drosophila* genetics, that tries to capture its material dimension in this sense, see (Kohler 1994).

REFERENCES

Allen, Garland E. 1986. T. H. Morgan and the split between embryology and genetics, 1910-1926. In *A History of Embryology*, edited by T. Horder, I. A. Witkowski and C. C. Wylie. Cambridge/Engl.: Cambridge Univ. Pr.

Bowler, Peter J. 1989. *The Mendelian Revolution: the emergence of hereditarian concepts in modern science and society.* Baltimore: John Hopkins Univ. Pr.

Braude, Benjamin. 1997. Sons of Noah. *The William and Mary Quarterly, 3rd Ser.* 54 (1):103-142.

Browne, Janet. 2002. *Charles Darwin: The Power of Place*. *Volume II of a Biography.* New York: Knopf.

Buffon, George Louis Leclerc Comte de. 1749. Premier Discourse. De la manière d'étudier et de traiter l'Histoire Naturelle. In *Histoire naturelle, générale et particulière, avec la description du cabinet du roi*. Paris: Imprimerie Royale.

– – – . 1791. *Natural history : general and particular. Translated by William Smellie.* 9 vols. London: Strahan and Cadell. Original edition, 1770-1784.

– – – . 1971. *De l'homme. Présentation de Michèle Duchet, Bibliothèque d'anthropologie.* Paris: François Maspero. Original edition, 1778.

Canguilhem, Georges. 1991. *The normal and the pathological*. Translated by C. R. Fawcett. New York, NY: Zone Books.

Canizares Esguerra, Jorge. 1999. New World, New Stars: Patriotic Astrology and the Invention of Indian and Creole Bodies in Colonial Spanish America, 1600-1650. *The American Historical Review* 104 (1):33-68.

Coleman, William. 1971. *Biology in the Nineteenth Century. Problems of Form, Function, and Transformation, Wiley History of Science Series*. New York: John Wiley.

Darwin, Charles. 1988. *The works of Charles Darwin. Vol. 20: Variation of animals and plants under domestication. Volume II*. New York, NY: New York University Press. Original edition , 1868.

Daston, Lorraine, and Katharine Park. 1998. *Wonders and the order of nature : 1150 – 1750*. New York: Zone Books.

Descartes, René. 1996. Primæ cogitationes circa generationem animalium et nonulla de saporibus. In *Oevres de Descartes. Vol. XI*, edited by C. Adam and P. Tannery. Paris: Vrin. Original edition, 1701.

Diggs, Irene. 1953. Color in Colonial Spanish America. *The Journal of Negro History* 38:403-427.

Foucault, Michel. 1966. *Les mots et les choses. Une archéologie des sciences humaines*. Paris: Galimard.

– – – . 1991. Faire vivre et laisser mourir: la naissance du racisme. *Les Temps Modernes* 535:37-61.

– – – . 1993. *Histoire de la sexualité. Vol. 1: La volonté de savoir.* Paris: Gallimard.

Galton, Francis. 1876. A theory of heredity. *Journal of the Anthropological Institute* 5:329-348.

Gayon, Jean. 1995. Entre force et structure: genèse du concept naturaliste de l'hérédité. In *Le paradigme de la filiation*, edited by J. Gayon and J.-J. Wunenburger. Paris: L'Harmattan.

– – – . 1998. *Darwinism's Struggle for Survival. Heredity and the Hypothesis of Natural Selection.* Cambridge/Mass.: Cambridge Univ. Pr.

Goody, J., Thirsk, J., Thompson, E.P., ed. 1976. *Family and Inheritance, Rural Society in Western Europe 1200-1800*. Cambridge: Cambridge Univ. Press.

Gregory, Andrew. 2001. Harvey, Aristotle and the Weather Cycle. *Studies in the History and Philosophy of the Biological and Biomedical Sciences* 32 (1):153-168.

Harvey, William. 1847. Exercises on the generation of animals. In *The Works of William Harvey.* Translated from the Latin with a Life of the Author by Robert Willis. London: The Sydenham Society. Original edition, 1651.

Heck, Kilian. 2002. *Genealogie als Monument und Argument. Der Beitrag dynastischer Wappen zur politischen Raumbildung der Neuzeit*. Vol. 98, *Kunstwissenschaftliche Studien*. München: Dt. Kunstverlag.

Hesse, Mary. 1974. *The Structure of Scientific Inference*. London: MacMillan Press.

Hodge, M. J. S. 1985. Darwin as a Lifelong Generation Theorist. In *The Darwinian Heritage*, edited by D. Kohn. Princeton: Princeton Univ. Pr.

Ibrahim, Annie. 1987. La notion de moule intérieur dans les théories de la géneration au XVIIIe siècle. *Archives de Philosophie* 50:555-580.

Jacob, François. 1993. *The Logic of Life. A History of Heredity.* Translated by B. E. Spillmann. Princeton, N. J.: Princeton Univ. Pr.

Johannsen, Wilhelm. 1911. The genotype conception of heredity. *American Naturalist* 45:129-159.

Jordanova, Ludmilla. 1995. Conceiving the New World Order. In *Interrogating the Concept of Reproduction in the Eighteenth Century*, edited by F. D. Ginsburg and R. Rapp. Berkeley: University of California Press.

Kielmeyer, Carl Friedrich. 1993. *Ueber die Verhältnisse der organischen Kräfte unter einander in der Reihe der verschiedenen Organisationen*. Edited by K. T. Kanz. Marburg: Basilisken-Presse.

Kohler, Robert E. 1994. *Lords of the Fly. Drosophila Genetics and the Experimental Life*. Chicago – London: Univ. of Chicago Pr.

Larson, James L. 1994. *Interpreting Nature. The Science of Living Form from Linnaeus to Kant*. Baltimore- London: John Hopkins Univ. Pr.

Lenoir, Timothy. 1980. Kant, Blumenbach, and Vital materialism in German Biology. *Isis* 71 (1):77-108.

– – – . 1982. *The Strategy of Life. Teleology and mechanics in nineteenth-century germany.* Chicago – London: The University of Chicago Press.

Lesky, Erna. 1950. *Die Zeugungs- und Vererbungslehren der Antike und ihr Nachwirken*. Vol. 1950, Nr. 19. *Abhandlungen der Geistes- und Sozialwissenschaftlichen Klasse der Akademie der Wissenschaften und der Literatur in Mainz.* Wiesbaden: Franz Steiner.

López Beltrán, Carlos. 2003. Heredity old and new: French physicians and *L'Hérédité* Naturelle in early 19th century. In *Conference: A cultural history of heredity II: 18th and 19th centuries*. Preprint 247. Berlin: Max Planck Institute for the History of Science.

– – – . 2004. In the Cradle of Heredity: French Physicians and L'hérédité naturelle in the Early Nineteenth Century. *Journal of the History of Biology* 37:39-72.

Lyon, John, and Phillip Reid Sloan. 1981. *From Natural History to the History of Nature: Readings from Buffon and his Critics*. Notre Dame – London: Univ. of Notre Dame Pr.

Mazzolini, Renato G. 1994. Il colore della pelle e l'origine dell'antropologia fisica (1492-1848). In *L'epopea delle scoperte*, edited by R. Zorzi. Firenze.

McLaughlin, Peter. 1982. Blumenbach und der Bildungstrieb. Zum Verhältnis von epigenetischer Embryologie und typologischem Artbegriff. *Medizinhistorisches Journal* 17 (4):357-372.

McLaughlin, Peter. 1990. *Kant's critique of teleology in biological explanation : antinomy and teleology.* Vol. 16, *Studies in the history of philosophy.* Lewiston: Edwin Mellen Press.

Müller-Wille, Staffan. 1999. *Botanik und weltweiter Handel. Zur Begründung eines Natürlichen Systems der Pflanzen durch Carl von Linn'e (1707-1778)*. Vol. 3, *Studien zur Theorie der Biologie*. Berlin: Verlag für Wissenschaft und Bildung.

Napoleons Gesetzbuch. Einzig officielle Ausgabe für das Königreich Westphalen. 1808. Straßburg: F. G. Levrault.

Olby, Robert C. 1979. Mendel no Mendelian? *History of Science* 17:53-72.

– – – . 1985. *Origins of Mendelism*. 2nd ed. Chicago – London: Univ. of Chicago Pr. Original edition, 1966.

– – – . 1993. Constitutional and Hereditary Disorders. In *Companion Encyclopedia of the History of Medicine,* edited by W. F. Bynum and R. Porter. London – New York: Routledge.

Pestre, Dominique. 2003. *Science, argent et politique. Un essai d'inerprétation*. Paris: INRA.

Pinto-Correia, Clara. 1997. *The ovary of Eve : egg and sperm and preformation*. Chicago [u.a.]: University of Chicago Press.

Pomata, Gianna. 2003. Comments on Session III: Heredity and Medicine. In *Conference: A cultural history of heredity II: 18th and 19th centuries*. Preprint 247. Berlin: Max Planck Institute for the History of Science.

Rey, Roselyne. 1989. Génération et hérédité au 18e siecle. In *L'ordre des caractères. Aspects de l'hérédité dans l'histoire des sciences de l'homme. Conférences organisées par Jean-Louis Fischer,* edited by C. Bénichou. Paris: Sciences en situation.

Rheinberger, Hans-Jörg. 1994. Morphologie bei Claude Bernard. *Aufsätze und Reden der Senckenbergischen Naturforschenden Gesellschaft* 41:137-150.

Rheinberger, Hans-Jörg, and Staffan Müller-Wille. in press. Gene. In *Stanford Encyclopedia of Philosophy* (http://plato.stanford.edu/entries/gene/).

Ritterbush, Philip C. 1964. *Overtures to Biology. The Speculations of Eighteenth Century Naturalists*. New Haven & London: Yale Univ. Pr.

Roberts, H. F. 1929. *Plant Hybridization before Mendel*. New York – London: Hafner.

Roe, Shirley. 1981. *Matter, Life, and Generation. Eighteenth-century embryology and the Haller-Wolff Debate*. Cambridge: Cambridge University Press.

Roger, Jaques. 1993. *Les sciences de la vie dans la pensée française du XVIIIe siècle*. Paris: Albin Michel: Bibliothéque de synthèse historique. Original edition, 1963.

Russell, Nicholas. 1986. *Like engend'ring like. Heredity and animal breeding in early modern England*. Cambridge: Cambridge University Press.

Sabean, David Warren. 1998. *Kinship in Neckarhausen, 1700-1870*. Cambridge: Cambridge Univ. Pr.

Schweber, Sylvan. 1977. The origin of the *Origin* revisited. *Journal of the History of Biology* 10:229-316.

Sloan, Phillip Reid. 1979. Buffon, German Biology, and the Historical Interpretation of Biological Species. *The British Journal for the History of Science* 12 (2 (41)):109-153.

– – – . 1995. The Gaze of Natural History. In *Inventing Human Science. Eighteenth-Century Domains,* edited by C. Fox, R. Porter and R. Wokler. Berkeley etc.: Univ. of California Pr.

Spary, Emma C. 1996. Political, natural and bodily economics. In *Cultures of Natural History,* edited by N. Jardine, J. A. Secord and E. C. Spary. Cambridge etc.: Cambridge Univ. Pr.

Sterne, Lawrnece. 1760. *The Life and Opinions of Tristram Shandy, Gentleman*. London: R. and J. Dodsley.

Stubbe, Hans. 1965. *Kurze Geschichte der Genetik bis zur Wiederentdeckung der Vererbungsregeln Gregor Mendels.* Vol. 1, *Genetik. Grundlagen, Ergebnisse und Probleme in Einzeldarstellungen.* Jena: VEB Fischer.

Waller, John C. 2003. Parents and children: ideas of heredity in the 19th century. *Endeavour* 27 (2):51-56.

Zirkle, Conway. 1935. *The Beginnings of Plant Hybridization*. Philadelphia: Univ. of Pennsylvania Pr.

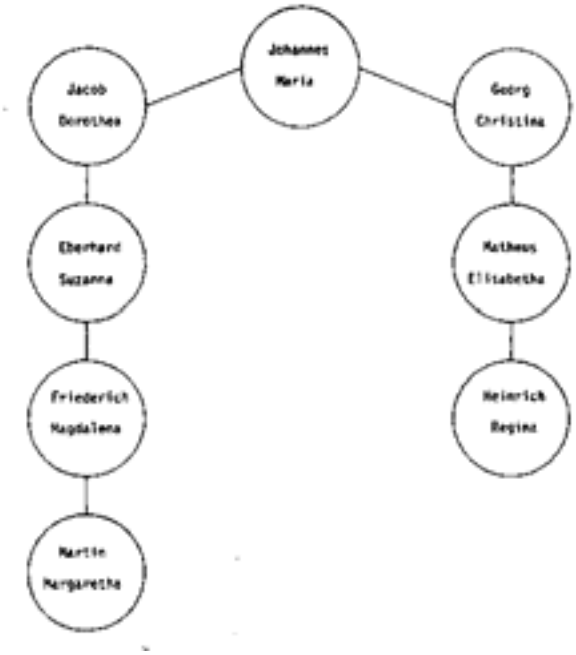

Fig. 1: According to the Germanic system Friedrich and Regina would be relatives in the third degree, as they are separated from their first common ancestor (Johannes) by three generations; according to the Roman system, in the sixth degree, as six “generations” (in the sense of generative events) lie between them.

Fig. 2: ‘Las castas’-painting from the early eighteenth century.