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A Cultural History of Heredity I: 17th and 18th Centuries

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Introduction

This volume assembles some of the contributions to the workshop "A Cultural History of Heredity I: Seventeenth and Eighteenth Centuries" which took place at the Max-Planck-Institute for the History of Science MAY 24-26, 2001.

The workshop was the first in a series of workshops dedicated to the cultural history of heredity. There are a number of histories of genetics written from the perspective of history of ideas. François Jacob's *La logique du vivant* (1970; engl. transl. 1973) and Robert Olby's *Origins of Mendelism* (1966, 2nd ed. 1985) have certainly set lasting standards in this field. There are also some sophisticated, far from whiggish histories written from a disciplinary perspective, like Hans Stubbes *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), to name just a few. What is missing, however, is a comprehensive study that embraces the cultural history of heredity by presenting the knowledge of heredity in its broader practical and historical contexts.

In our project we wish to focus on the scientific and technological procedures, in which the knowledge of heredity was materially anchored and by which it affected other cultural domains. Such a project will be content neither with conventional history of ideas nor with mere social history. It will rather explore the various practices, standards, and architectures of hereditary knowledge and the "spaces" which they formed by their respective historical conjunctions. "Heredity", under this perspective, is more than the scientific discipline "genetics". The project is less about the history of a science than about the history of a broader knowledge regime, in which a naturalistic conception of heredity developed historically that today affects all domains of society. This knowledge regime dates back to the social illusions and illuminations of the Enlightenment. What does it mean that nature determines history so that it appears as if history could be controlled by nature? And: are we today, with the advent of gene technologies, witnessing the end of a deterministic world view, or are we confronted with its definite restoration?

A project like this is vitally dependent on the participation of experts from a broad range of disciplines, covering cultural history in its various subdomains of science, technology, medicine, politics, economy, law, literature, and art. It will be pursued in a series of workshops, each focussing on a loosely defined "epoch" characterised by a certain development in hereditary knowledge.

The first workshop, organized by *Hans-Jörg Rheinberger*, *Peter McLaughlin* and *Staffan Müller-Wille*, concentrated on the late seventeenth and the eighteenth century and assembled historians of science, medicine, politics and literature from the United States, Mexiko, Germany, Switzerland, and Italy. Four poapers presented at this workshop make up this volume. Discussion during the workshop turned around two main questions: 1), if a concept of heredity existed at all in this period; and 2), in how far 18th century theories of generation were guided by empirical experience.

In regard to the first question, several contributions could show that there was no general concept of heredity underlying the discourse of the life sciences (Fantini, Terrall). However, there did exist some isolated, well-defined and sometimes, especially in breeding and medicine, highly localised fields structured by the recognition of hereditary transmission of differential characters

in the 18th century – the definition of specific difference in natural history (Müller-Wille), the explanation of hereditary diseases in pathology (Lopez-Beltran), political organisation of colonial societies according to racial characteristics (Mazzolini), and the application of hybridisation in plant (Ratcliff).

In regard to the second question, the workshop disclosed a rich spectrum of theoretical approaches to generation in the 18th century and made clear that this diversity is only insufficiently captured by the conventional dichotomy of preformation vs. epigenesis (Fantini, Terrall). This spectrum, however, was rather determined by different positions in regard to the politics and poetics of production, both experimental and social, than by a secured and well-defined domain of empirical data (Müller-Sievers, Roe, Terrall).

Future workshops in the series follow a very rough chronological order. Their thematic structure will be developed from the results reached in the preceding workshop. The folllowing list of planned workshops, therefore, indicates in a very preliminary way how the project will proceed:

Eighteenth to Nineteenth Century: Heredity Becomes Central (January 10-12, 2003)

This workshop will focus on the period demarcated by the publication of Kant's *Von den verschiedenen Rassen der Menschen* 1775 and Darwin's *The Variation of Animals and Plants under Domestication* 1868. This "epoch" in the cultural history of heredity was characterised by a decisive development at the end of which stood the establishment of "inheritance" as one of the central problems of the life sciences. Parallel to this shift one can observe conceptual displacements: Heredity began to be conceptualised as a relation between parental and filial dispositions, rather than between over-all constitutions. Accordingly, theory formation began to revolve around the production and combination of traits within a species rather than around its over-all morphology. Finally, adaptation (or degeneration) under changing conditions, rather than a pre-established balance of nature, became its general framework. Four fields have preliminarily been identified in which these displacements took place: natural history, breeding research, medicine (including psychiatry), and anthropology.

Nineteenth to Twentieth Century: Heredity Becomes Exact

This workshop will cover the period from Galton's *Hereditary Genius* to the formulation of a thoroughly mathematical populations genetics in the 1930s. Population thinking and statistics replace the taxonomic regime of race and character, that previously provided the conceptual framework for hereditary knowledge. The historical background for this development can be seen in the social transformations triggered by industrialisation and concurrent eugenic visions of regulating and controlling populations, including their notorious 20th century versions.

Early Twentieth Century: Heredity Becomes Molecular

Molecular genetics did not immediately result from the developments characterised in the previous workshop, but from a plurality of methodological achievements in other biological domains, few of which had to do with genetics. The result of these conjunctions, however, was a further naturalisation of hereditary thought with the "cracking" of the genetic code. Heredity was

brought down from the structural level of populations and genetic traits to a material level of molecules capable of being "read", "copied", "translated", and "transmitted", be it in human bodies, be it in laboratories. The question of genetic determination and control thus gained renewed prominence after the demise of eugenics.

Late Twentieth Century: Heredity Becomes Technological

The field of heredity was again thoroughly transformed with the advent of "gene technologies". Potentially all areas of social life are affected by these practices, and their application in medical and industrial contexts open up perspectives whose limits are typically not foreseeable. Gene patenting, DNA-fingerprinting, gene therapy, and cloning are areas hotly debated in this regard. For the discipline, moreover, the question arises how future research will be oriented after the sequencing of large genomes has become routine work. With the *longue durée* historical perspective provided by the previous workshops we hope to gain innovative, even surprising outlooks on these problems of the day.

Hans-Jörg Rheinberger
Peter McLaughlin
Staffan Müller-Wille

Cabbage, Tulips, Ethiopians – "Experiments" in Early Modern Heredity

Staffan Müller-Wille

0. Introduction

Genealogy is the oldest logic. Not only do the key concepts of ancient logic – *γενος* and *ειδος* – have genealogical connotations, but even the way in which these concepts were seen to relate deductively was modelled on genealogy: *ειδος* and *γενος* relate in the same way "as Agamemnon is an Atride, a Pelopide, a Tantalide, and finally of Zeus", as it says in Porphyry's *Isagoge* to Aristotle's *Categoria*.[1] Some identity persists in descending genealogies, and thus things can be inferred for individuals by retracing their origin (*αρχη* or *principium*, again a term with a genealogical connotation) through the chain of their antecedents.[2]

And yet, the old world, as is well known, was a world full of monstrous births, strange transmutations and unnatural copulations. Though Aristotle, e. g., repeatedly maintained that "a man is generated by a man",[3] he equally conceded the possibility that "two animals different in species produce offspring which differs in species; for instance a dog differs in species from a lion, and the offspring of a male dog and a female lion is different in species".[4] And still in 1690 we see no one less than John Locke resuming in his *Essay concerning human understanding* that he "once saw a Creature that was the Issue of a Cat and a Rat, and had the plain marks of both about it."[5] As fantastic as this promiscuity of nature – in which every combination seemed as plausible as possible – may seem to modern eyes, it rested on a rational ground: The foundation for the similarity among parents and offspring was provided by the recurrence of similar physiological and climatic conditions during procreation and development, which, inversely, meant that any deviation from this ordinary course of things – e. g. mesalliances as the ones referred to by Aristotle and Locke – would produce as deviant results. "All things are governed by law" is the conventional translation for the opening sentence of a Hippocratic tract *De genitura*.[6] Yet, it is worthwhile to consult its Renaissance Latin translation: "*Lex quidem omnia corroborat*" – "Law strenghtens" – the original indeed has "*κρατυνει*", which signifies both strengthen and govern – "everything", with "law (*νομος*)" – as the commentator Girolamo Mercuriale carefully noted –

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1 Porphyrius (1887), 2b1-4, p. 6. The full text in its Latin translation by Boethius (ibid, p. 31) is: "ea vero quae sunt ante specialissima usque ad generalissimum ascendentia et genera dicuntur et species et subalterna genera, ut Agamemnon Atrides et Pelopides et Tantalides et ultimum Jovis." Cf. Porphyrius (1998), I 1-3, II 9.

2 Cf. Heinrich (1981), pp. 98-100, also Gayon and Wunenburger (1995), p. 8: "[...] la valorisation des filiations historiques, des ascendances et descendances d'un être, a longtemps servi de vecteur quasi unique d'intellegibilité canonique".

3 E. g. Aristotle *De gen. anim.* 735a20. Cf. Lesky (1950), p. 139, for further references and discussion.

4 Aristotle *De gen. anim.* 747b33-36. Aristotle refers to this as an "abstract argument" in the discussion of mules, which are infertile, yet, as he himself states (ibid 748a16), he gave a wealth of examples for such "hybrids" in both *De generatione* and *Historia animalium*. Cf. Zirkle (1935), pp. 15-17.

5 (Locke ([1690] 1975), p. 451, §23. For a rich account on such "hybrids" through history see Zirkle (1935), for iconographical evidence also Daston and Park (1998).

6 E.g. Lloyd (1978), p. 317. Cf. the French translation – "La loi gouverne tout" – in Hippocrates (1851), p. 471.

meaning "customs, pasture, region, class (*instituta, pascua, regionem, classem*)" in the dialect of the Hippocratic texts.[7] Genealogy was seen to consist less in relations resulting from the lawful transmission and redistribution of some hereditary material but rather in the local persistence of economical, political and social configurations, in the persistence of a "fabric"– as Claude Lévi-Straus has formulated it – "in which warp and filling yarn correspond to localities and tribes".[8] In this context, heredity was at once something trivial and precarious: It was stabilised and reinforced by the persistence of its own, municipal bounds (local rules of marriage and residence), and yet remained infinitely open to disturbances by illicit transgressions of these bounds.[9]

It is, I presume, behind this background that we must see the achievements of the 18th century in regard to the formation of a modern concept of heredity. Peter Bowler has rightly argued, I think, that one important condition had to be fulfilled, before one could speak of such a concept: a clear distinction had to be drawn "between the transmission of characters from one generation to the next and the process by which the characters are produced in the growing organism".[10] As an indication of how difficult it is, indeed, to see this, I take it that one 18th century theory of organic reproduction, in which this precondition seems to have been fulfilled – if only to a certain degree, which is the very topic of this paper – has consistently been underrated, if not simply overlooked, by historians of 18th century theories of organic reproduction.[11] I speak of the theory of organic reproduction of Carolus Linnaeus.

1. Laws of generation

One of the reasons for the neglect of this theory by modern historians may be the place and the form in which it first appeared: Linnaeus laid out his theory not – as one might expect – in a coherent tract on the physiology of generation, but in a set of short aphorisms introducing the first editions of his famous taxonomic works, the *Systema naturae* of 1735 and the *Genera plantarum* of 1736.[12] Moreover, it did not enter the scene as an independent account on the mechanisms of propagation, but was contained in the definition of a central category of Linnaean taxonomy: the species. Let us first have a close look at this definition:

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7 Hippocrates (1588), p. 10 & 15. Cf. Stubbe (1965), pp. 18-21. I thank Volkmar Schüller and Friedrich Steinle from the Max-Planck-Institute for the History of Science, Berlin, for discussing this passage with me.

8 Lévi-Strauss ([1962] 1969), p. 97.

9 Cfr. ch. 2 "La logique des classifications totémiques" in Lévi-Strauss (1962), pp. 48-99, who explicitly subsumes "the naturalists and hermetics of antiquity and the middle ages: Galen, Plinius, Hermes Trismegistos, Albert the Great" (ibid, p.57) under his analysis.

10 Bowler (1989), p. 6.

11 Lippmann (1933), pp. 49, 63 & 78, Cole (1930), pp. 18 & 137 and Roger ([1963] 1993), p. 322 mention Linnaeus only in passing. Ritterbush (1964), pp.101-103, though discussing Linnaeus' theory of (plant) reproduction at length, tries to side him in the debate between "ovists" and "pollenists", an opposition Linnaeus discarded, as we shall see. Delaporte (1983), pp. 124-127 discusses the anthropomorphism of Linnaeus' theory of reproduction, but otherwise misses its idiosyncrasies. Interestingly, and rightly so, as we shall see, Linnaeus is compeletely missing in François Duchesneau voluminous study of 18th century physiology.

12 Far from reducing the impact of Linnaeus' theory of reproduction, this place rather had the effect that it "swept all of Europe and North America". Cf. Farley (1982), p. 5.

> There are as many Species as different forms produced by the Infinite Being in the beginning. Which forms afterwards produce more, but always similar forms according to inherent laws of generation; so that there are not more Species now than came into being in the beginning. Hence, there are as many Species as different forms or structures of Plants occurring today, those rejected which place or accident exhibits to be less different (varieties).[13]

This short, and in its brevity so concise, passage has been endlessly quoted as indicating Linnaeus's adherence to a "typological" species concept.[14] And yet, as a close reading reveals, it does not so much tell us, *what* species are, but rather *how many* there are *on the assumption of certain "laws of generation"* . If we analyse Linnaeus's species definition with regard to these laws, three peculiar *absences* come to the fore, which on the one hand set off this theory from contemporary theories of generation and on the other hand indicate its propensity towards the modern concept of heredity:

1. The subjects of Linnaeus's "laws of generation" are not substances – seminal principles, moules interieures or the like – but "forms or *structures*". "*Structura*" – in contrast to the much more wider term "*forma*", which the definition uses synonymously – means something highly specific in Linnaeus's terminology: It designates the totality of characters differentiating the members of a species from all other species according to "all its parts [...] in four dimensions: number, form, proportion, position".[15] The similarity relation posited among parents and offspring "according to inherent laws of generation" is one of mere structural analogy, not of substantial contiguity. There are two peculiar consequences to this: First, that the traditional "three tier" set-up of the problem of heredity – heredity of generic, sexual and individual traits – does not play, as far as I can see, the least role in Linnaeus's writings on organic reproduction.[16] Sexual and individual differences – ontogenetic as well as intraspecific differences, e. g. in the number of certain organs – simply collapse with generic differences as they become differences within one and the same structural whole.[17] And second – as is also clear from the stress put on the number, rather than the essence, of species –, that the order reigning between species is not a contiguous "scale of being" but a simple juxtaposition of discrete entities, without overlaps or intermediates.[18]

2. The second absence within Linnaeus's theory of reproduction is the absence of "physiology". If one follows the "laws of generation" referred to by the definition, up to their full explication in the

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13 Linné (1737), Ratio operis §5, [p.2]: "*Species* tot sunt, quot diversas formas ab initio produxit Infinitum Ens; quæ deinde formae secundum generationis inditas leges produxere plures, at sibi semper similes, ut Species nunc nobis non sint plures, quam quæ fuere ab initio. Ergo Species tot sunt, quot diversæ formæ seu structuræ Plantarum, rejectis istis, quas locus vel casus parum differentes (Varietates) exhibuit, hodienum occurrunt."

14 For the locus classicus of this interpretation see Mayr (1957).

15 Linnaeus (1736), §92, p.11. Cfr. ibid, § 326, p.32.

16 Olby (1966), p. 1, describes this set-up, which, e. g., was still shared by Buffon, as one of the main obstacles on the way to the modern (Mendelina) concept of heredity.

17 Thus Linnaeus designated sexual dimorphism as a "natural variety (varietas naturalis)"; Cf. Linnaeus (1736), § 308, p. 30. A particular good example for the collapse of generic, sexual, and individual differences is provided by the description of the "structure" of the genus *Urtica* in the *Genera plantarum*, where one line says: "Female flowers, either in one or two different plant individuals". (Linnaeus 1737), p. 283. This collapse is why Linnaeus was prepared to accept "constant varieties (varietates constantes)" – i. e. distinct and constantly reproducing forms within one and the same species –, in later writings on the reproduction of plants (see Linnaeus ([1755] 1788), pp. 380-383). I will come back to that in the section on "Ethiopians".

very first two paragraphs of the *Systema naturae* of 1735, it becomes evident, that the substrate of the structural similarity posited between ancestors and descendants is made up of purely genealogical relations. All in all, these two paragraphs formulate three basic laws: a) that "individual living beings are propagated by the egg (*viventia singula ex ovo propagari*)"; b) that "each egg produces offspring similar to the parents (*omne ovum producere sobolem parenti simillimam*)"; and c) that "individuals are multiplied by generation (*ex generatione multiplicantur individua*)".[19] Translated into negative statements, the first two "laws" reject any possibility for spontaneous generation or transmutation: No generation can occur outside the context of genealogical relations and no generation can transgress the bounds of this context. The only change that does occur is one in the number of individuals. That "*ovum*", the fertilised egg, does not represent a physiological unit (in the sense, e. g., in which it does in William Harvey's work), but simply that entity which mediates generations of parents and offspring, can be inferred from another paragraph of the introduction to the *Systema naturae*, where Linnaeus states that "natural bodies are made up of elements, but in a way inexplicable except for creation and laws of generation."[20] Consequently, Linnaeus did not side himself in the debate between animalculists/pollenists and ovists, but rejected both versions of preformation with the (basically genealogical) argument, that both parents, male and female, enter into the procreative act to leave traces in the offspring (which, of course, was known to preformationists) and that otherwise "it remains an obscure matter, now and once, how generation or fertilisation happen".[21]

3. The third absence in Linnaeus's theory of organic reproduction is explicit in his formulation of a species concept: "[T]hose [structures are to be] rejected which place or accident exhibit to be less different (varieties)." Though formulated in a rather awkward way, the message is clear: Linnaeus draws a distinction between structural differences distinguishing organisms on a generic (species) level and obeying the laws of generation, and structural differences distinguishing organisms on the level of individuals and being due to local, accidental causes – "climate, soil, heat, wind", as a later formulation of this distinction in the *Philosophia botanica* (1751) has it.[22] In modern words: Linnaeus drew a distinction between nature and nurture, the latter's effects being excluded from the realm of "laws of generation". Accordingly, and in stark contrast to contemporary theories of generation, Linnaeus's theory of reproduction, even in its later, more elaborated versions, does not show the least trace of the age old theories of pangenesis and "inheritance of acquired characters".[23]

I take all three abstractions – the absence of substance, the absence of physiology, and the absence of environment – to be hallmarks of the distinction of transmission and development

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[18] That there are no intermediates between species and, by extension, genera is frequently stressed in Linnaeus's *Critica botanica*; see, e. g. Linnaeus (1737a), §224, p. 29. As is well known, Linnaeus rejected the "scala" in favour of the map as representing relations among generic entities (cf. Linnaeus (1751), §77, p. 27). For a discussion see Rheinberger (1986) and Müller-Wille (1999), pp. 89-97. Barsanti (1995), p. 35, considers the map, instead of the scale, to be the "image plus apte à acceullir une logique de filiation".

[19] Linnaeus (1735), §§1-2, [p. 1].

[20] Ibid, §7, [p. 1]: "Naturalia illa ex elementis constructa, licet modo, praeter creationem & leges generationis, inexplicabili." For Harveys concept of "ovum" as a fundamental physiological unit, which, e. g., also could effect spontaneous generation of living beings, see Jacob (1970), pp. 63/64.

[21] Linnaeus ([1746] 1749), p. 347: Quomodo fiat generatio, vel fecundatio, innumerae sententiae Physiologorum fuerunt; sed aeque ac olim obscura res est." Cfr. ibid, p. 349.

[22] Linnaeus (1751), § 158, p. 100.

which according to Bowler was vital for the formation of the modern (Mendelian) concept of heredity, with the important limitation, however, that in Linnaeus's theory of organic reproduction "transmission" did not consist in the redistribution of independent characters, but in the universal persistence of a totality of characters, i. e. of "structure" (I will come back to this in the end of my paper). To be sure, also, Linnaeus later supplemented his theory with a physiological model of generation, which, interestingly, however, hypostatised the abstractions inherent to the earlier formulation of "laws of generation": According to this model, all organisms consist of two, antagonistic substances: the inner "pith (*medulla*)", which is propagated via the maternal line, and has a "power of infinite multiplication" (in animals, this substance corresponds to the nervous system). And the outer "bark (*cortex*)", which is propagated via the paternal line and has the power to attract and conduct nutriments, thus nourishing and protecting the medulla, and thus controlling its growth. The medulla, to put it shortly, is a merely propagative, the *cortex* a merely distributive substance, and it is their balanced, yet inherently antagonistic interaction through which life is maintained and develops.[24] One of the earliest formulations of this physiological model in the *Philosophia botanica* 1751 shows, how closely it was tied to Linnaeus's peculiar theory of generation:

> The root [containing the pith] extends infinitely, until the integuments [i. e. the bark] break up at the top to form the flower, and the seeds develop as the continuation and the utmost end of vegetation. This seed falls down, sprouts, and sort of continues the plant at a different place. Thus similar offspring is produced as the tree produces the branch, the branch the bud, and the bud the plant; therefore the generation of plants is a continuation.[25]

As much as some of the assumptions within Linnaeus's theory of reproduction seem to be evident in the context of modern biology – as the rejection of spontaneous generation and transmutation, or the distinction of environmentally induced variation and "genetic" determination – at their time they were very strong claims. The strength of these claims, however, stood in a peculiar contrast to their empirical foundation. In the *Fundamenta botanica* of 1736, e. g., the sentence "*Omne vivum ex ovo*" is just said to be "repeatedly asserted by reason and experience and confirmed by the cotyledons".[26] If this already seems to be a rather weak, arbitrary, and ad hoc substantiation of the claim in question, even more so do Linnaeus's references to "experiences (*experimenta*)" in his first published essay on the reproduction of organisms, the

[23] See Zirkle (1946) for rich material of the occurrence of these beliefs in the eighteenth century. Linnaeus did speculate sometimes, that certain plant species had resulted from the prolonged exposition of other species to a different climate or to intense cultivation (cfr. Ramsbottom 1938). This was also the basis for his attempts to "acculturate" exotic plants like tea to the climate of Sweden (cf. Körner 1994). Linnaeus remained undecided, however, if these changes were not reversible, and thus just special cases of "varieties" (e. g. Linnaeus (1737a), §316, p. 255).

[24] See, e. g., Linnaeus ([1759] 1763). For a detailed discussion of this theory see Stevens and Cullen (1990).

[25] Linnaeus (1751), § 157, p. 99: "Radix extenditur in herbam inque infinitum, usque dum apice rumpantur integumenta in florem, formantque semen contiguum, ultimum terminum vegetationis; Hoc semen cadit, prognascitur, & in diverso loco quasi plantam continuat; hinc simillimam sobolem producit, uti Arbor ramum, Ramus gemmam, Gemma herbam; ergo Continuatio est generatio plantarum." Ibid, §79, p. 37, identifies the extending root with the medullar, and the integuments with the cortical substance.

[26] Linnaeus (1736), §135, p. 16: "Omne vegetabile ex ovo (134) provenire dictitat ratio & experientia, confirmant cotyledones."

Sponsalia plantarum of 1746: To modern eyes they just appear as a potpourri of chance observations, poorly designed experiments, just-so stories and circular reasonings.[27] Yet, a closer look at these empirical references is necessary to identify a historical space for the formation of Linnaeus's "laws of generation" and to reach a better understanding of their position in the cultural history of heredity.

2. Ethiopians

The bulk of the *Sponsalia plantarum* tries to identify the sexual organs of plants in analogy to animals, and employs morphological arguments for this aim. Among this, however, we find a few, which refer to what we today would call hereditary phenomena. One of them is especially intriguing, as it appeals to an experiential background, that was shared by the learned since antiquity: the "blended" character of children resulting from interracial "crossings" among humans of African and European origin.[28] Yet, Linnaeus did not leave it at a general reference to this experiential background, but quoted a particular example from literature in the following words:

> "A common Ethiopian detained in the Copenhagen prison and kindled with love for a maid, secretly slept with her. Pregnant from that, and after due time of bearing, was brought forth a child of male sex, which resembled the mother in the whiteness of skin all over the body, only the darker penis showing the kind of its father." Barthol. cent. 4. obs. 5. Which all evinces, that the beginnings of the coming fetus by no means lie hidden in one sex only.[29]

That Linnaeus chose to quote this instance, rather than to report a general experience, has certainly to do with the "empirical weight" gained by the authority of its source: The quote is from the *Historiarum anatomicarum rariorum centuria* which Thomas Bartholin (1606-1680), influential professor of medicine and theology at Copenhagen university, published in four volumes 1656 and 1657, each volume containing a *centuria* (a hundred) of "histories". This format, also used by Bartholin in his *Epistolarum medicinalium à doctis vel ad doctos scriptarum* 1663-1667, appears rather strange to modern eyes: Completely unrelated observations of various medical interest – dissection reports, observations of unusual phenomena, cures and receipts, clinical cases – follow each other without any attempt at a systematisation. The headings of the first ten histories – including the one quoted by Linnaeus – of the fourth *centuria* may illustrate this:

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27 Cf. Sachs (1875), p. 104-106, whose reading of the *Sponsalia plantarum* has long influenced the picture of Linnaeus as a poor empirist.

28 That such "crossings" were common in the Mediterranean of Antiquity is clear, and thus we find frequent references to them in the writings of ancient natural philosophy (e. g. in Aristotle, cf. Stubbe (1965), p. 21). How continuous these contacts remained even in Central Europe of the Middle Ages is discussed at length in Martin (1993).

29 Linnaeus ([1746] 1749), p. 349: "‚*Æthiops* cerdo in ergastulo Hafniensi detentus, amore puellæ servæ accensus, clanculum illam compressit. Gravida inde, legitimo partus tempore enixa est prolem virilis sexus, quæ matrem universo corpore cutis candore referebat, solus vero penis paternum genus nigrore commonstravit. Barthol. cent. 4. obs. 5.' Quæ omnia, rudimentum futuri fœtus neutiquam in uno tantum sexu delitescere, evincunt."

I *Anatome Civettae* (Dissection of a civet cat)

II *Prolapsus uteri cum urinae incontinentia* (Prolapsus with incontinence)

III *Convulsiones paralyticae* (Paralytic convulsions)

IV *Unicornu Groenlandicum* (Greenlandian unicorn)

V *Ex Aethiope natus* (Birth from an Ethiopian)

VI *Anatome Hominis sanis* (Dissection of a healthy man)

VII *Epilepsia ex vermibus* (Epilepsy from worms)

VIII *Calculus ex scroto suppuratu* (Stone gathered from a scrotum)

IX *Emplastra magna* (Large plasters)

X *Anatomi Monachi* (Dissection of a monk)

This "aphoristic" make-up was not used in deficiency of a system or theory, as Lorraine Daston has argued, but rather to avoid the pitfalls of speculation, to immunise the gathering of observations from rash conjecture and system building to enhance their "facticity".[30] Yet this very format entailed a difficulty in regard to the empirical foundation of Linnaeus's theory of generation, which comes to the fore, if we compare Linnaeus's quote with the original text of Bartholin:

> A common Ethiopian detained in the Copenhagen prison and kindled with love for a maid, secretly slept with her. Pregnant from that, and after due time of bearing, was brought forth a child of male sex, which resembled the mother in the whiteness of skin all over the body, only the darker penis showing the kind of its father, which several people eye-witnessed and wondered at. I assign this wholly to the imagination of the mother, which seizing the desired part with a fixed and vigorous mind, impressed its colour on the offspring. Of mixed colour are children otherwise brought forth from an Ethiopian and a white, which often shows us, how both sexes have their separate commands over generation.[31]

What Linnaeus leaves out in his quote is what is interesting to Bartholin, while what Linnaeus tries to prove by his quote is what Bartholin takes for granted, as something known anyway. Bartholin concentrates on those features of the case reported – the fact that the colours do not blend in the child, as is usual, but remain seperated – which single it out as a singular case. And consequently, he is looking for singular circumstances in this case (the passion of the mixed couple, which, as it seems, was looked upon as something unusual by Bartholin) in search for an explanation. Only by leaving out this argument, and by reformulating the general conclusion, could Linnaeus adapt Bartholin's observation to his theory of generation in which a combination of structural

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30 Cf. Daston (1998).

31 Bartholinus (1657), pp. 220-221: "Æthiops Cerdo in Ergastulo Hafniensi detentus, amore puellæ servæ accensus, clanculum illam compressit. Gravida inde legitimo partus tempore enixa est prolem virilis sexus, qvæ matrem universo corpore cutis candore referebat, solis verò penis paternum genus nigrore prodebat, qvod oculati testes plures & viderunt & mirati sunt. Imaginationi matris id universum assigno, qvæ partem vehementis desideratam animo fixo comprehendens ejusdem colorem fœtui impressit. Mixti |221| aliàs coloris solent fœetus ex Æthiope & alba procreari, qvod sæpe nobis visum, si qvidem uterq; sexus divisum in generatione imperium habet."

differences in the offspring rather was to be expected than posed a problem, and in which such developmental causes as "maternal imagination" did notably not play a role. Quite in line with this, the problem that Linnaeus saw in the well known case of "Ethiopians" was not to explain that and how their skin colour persisted, but rather that they possessed a distinctive character – black colour – that remained constant even under varying climatic and geographic conditions, while they nevertheless doubtlessly belonged to the same species as other humans: "Who would deny that the Ethiopian is of the same species as we humans", as it says in a paragraph discussing difficulties in distinguishing varieties from species in the *Critica botanica* (1737), "and yet the Ethiopian brings forth black children in our countries."[32]

What this shows, is that something more than isolated observations of hereditary phenomena had to enter the scene before Linnaeus' could formulate his "laws of generation". These laws, as we saw, transcended the bounds of individual parentage, and only in hindsight could the numerous isolated instances of inheritance reported in medicine and natural history appear to Linnaeus as approving his laws. What is missing is an empirical context in which the hereditary relations constitutive of Linnaeus' theory of organic reproduction were actively implemented to reach beyond the exceptional and the ordinary course of things. The problem of the historical formation of this theory is one of synthesis, of how to knit together hereditary phenomena to form a network of relations rather than a number of individual cases.[33]

3. Tulips

For understandable reasons, this problem of synthesis could not be solved in anthropology. A much better candidate for that would have been plant and animal breeding, and the *Sponsalia plantarum* indeed abound with examples taken from this ancient realm of technology. A particular interesting example, as it expressly referred to an "experiment", is the following:

> TULIP. Delightful is this horticultural experiment: If someone perchance rejoices in completely red tulips and tears out the anthers from some flower before the pollen is scattered, and afterwards takes a tulip with a white flower and sprinkles the other, red one's stigma with its anthers; and finally puts the ripe seeds in their own bed, he will obtain in this bed some red, some white, and for the greatest part two coloured flowers, no less than variously coloured offspring is produced from two animals of different colour.[34]

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[32] Linnaeus (1737a), §316, p. 255: "Quis neget æthiopes esse ejusdem speciei ac nos homines, tamen æthiops nigros procreat infantes, in nostra terra". This problem of "constant varieties" became more and more pressing for Linnaeus, resulting in the development of a theory of hybridization to account for the rise of new species and varieties from 1751 on. Cf. Müller-Wille (1998). For Linnaeus's classification of human races according to skin colour, which he already presented in his *Systema naturae* of 1735, see Sloan (1995).

[33] The "aphoristic" style of Bartholin resembles that of the "consilia", a collection of court cases which was posthumously added to Paolo Zacchias' *Quaestiones medico-legales* 1621-1650. This latter publication contained, among other topics, a systematic exploration of ancient and early modern theories about "the similarity and dissimilarity of children (*De similitudine & dissimilitudine natorum*)", reaching the conclusion that both male and female have "equal potentials" in the "process of generation" (see Bajada (1988), pp. 23-60, who calls the *consilia* a collection of "experiments"; ibid. p. 31). This forensic context, in which Bartholin was active too (see *Dansk Biografisk Leksikon*, Copenhagen 1979, vol. 1, pp. 475-6) and which may very well have been a source of "synthesis" of individual cases, could not be explored in this paper.

The "experiment" Linnaeus recounts here came from a well known historical background: Not only had the trade in tulip varieties – after their introduction to Europe by the Turks in the early sixteenth century, Matthias L'Obel already could include illustrations of 20 different sorts in his *Kruydtboeck* of 1581 – been responsible for the first emergence of widespread, public option trading and ensuing market crash in the Dutch "tulip craze" 1633-1637;[35] this trade also sparked off an intense activity of breeding new varieties of tulips which survived the "craze".

But far from praising this activity as giving insights into the "laws of generation", we see Linnaeus complaining about it elsewhere, namely in his *Critica botanica,* curiously enough invoking just the example of tulips:

> The prime reason why [our] precursors came out with wrong species names only consisted in that they refused to distinguish natural characters and parts, or certain ones from sportive ones. As they accepted all characters, accidental and natural ones alike, they erected new species from the most insignificant character, from whence so much confusion, such a barbarity of names, such an accumulation of wrong species, that it were easier to clean the stable of Augias, than that of Botany. [...]
>
> Certainly, if each character would equally constitute new species, there would be no wiser and accurate Botanists among mortals than those FLOWER-LOVERS, who each year in tulips, primroses, anemones, daffodils and hyacinths alone present to the curious thousands [of plants] unknown to the Botanists, and hence new species. [However:] The Omnipotent Builder of Creation stood off from work on the seventh day, so that there is no new creation each day, but a continuous multiplication of things once created. He created one human, as the Holy Scripture teaches: but if the smallest character were enough, there would stand out thousands of human species today; there stand out namely [those] with white, red, black, doggish [?] hair; with white, pink, brown, black face; with erect, short, curved, snub, aquiline nose; there stand out giants and pygmies, fat and thin, straight and bowed, leprosic [?] and lame people etc. etc. Yet who would ever lightheadedly [?] call them different species? You see, therefore we assume certain characters, and look for the deceptive ones, which lead astray and do not change the thing. [... e. g.], Tournefort counts 93 Tulips (where there is only one) and 63 hyacinths (were there are only two), and no less do others sport in others.[36]

But not only do such "flower-lovers (*anthophili*)" as Tournefort – who in fact was counted among the greatest botanists in Linnaeus's time – burden botany with trivial distinctions and wrong species; Linnaeus even believed that they were to count as no botanists at all:

> Flower-lovers and Botanists have the same objects in varieties, however, with the difference, that the Flower-lover enters the scene, where the Botanist leaves it. The latter, sort of weary of it, sets an end to the work; the former, vigorous, begins to build that he may reach the stars.[37]

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[34] Linnaeus ([1746] 1749), p. 370: "TULIPA. Jucundum est horticulturæ experimentum: si forsan rubris tantum gaudeat Tulipis, in flore aliquo antheras omnes decerpat ante pollinis dispersionem, assumat deinde Tulipam flore albo hujusque antheris stigma alterius rubræ aspergat6; maturis deinde seminibus, eadem in areolam propriam projiciat, & in hac areola flores reportabit, alios rubros, alios albos, bicolores plerosque ceteros, haud secus ac ex duobus animalibus diversi coloris, fœtus variis decoratus coloribus producitur." Examples from animal breeding – mules, hens, dogs and sheep – are listed on p. 349.

[35] Cf. Jessen (1864), pp. 256-257, Kulischer ([1929] 1988), pp. 319-320, Zirkle (1935), p. 88.

And, as a comment to his own, consequent dictum, that the "botanist does not care for those fortuitious monstrosities and varieties (*casuales monstroisitates varietatesque [...] non curat Botanicus*)", Linnaeus added in obvious allusion to his species concept:

> The number of species of Botanists remains the same, now or in the future, as when they poured out of the hand of the Omnipotent Creator. Of the Flower-lovers, however, new and different ones are produced each day from the species (as the Botanists call them), and descended from these they finally ruin them. To the former, therefore, [i. e. the species of Botanists], there have been set certain limits by nature, which cannot be transgressed; in the latter, however, there is an infinite sport of nature without end; the former's species come from the all-wise hand of the Omnipotent, the latter's varieties from the sport of nature, especially under the auspices of the gardeners. From hence the greatest difference between Botanists and Flower-lovers.[38]

I have quoted Linnaeus here at length, because it is not easy to see, why Linnaeus so polemically criticised the "*Anthophili*", who, after all, seem to have provided him with a "delightful experiment" to back his theory of organic reproduction. It is not a difference in "scientificity", as the mentioning of Tournefort as one of the proponents of the "*Anthophili*" proves.[39] It is equally not a difference in the realm of objects studied by Botanists and flower-lovers respectively: Varieties are said to be as much a topic for botanists as they are for Flower-lovers. The best way to describe the divide raised between botanists and flower-lovers by Linnaeus is to say that it is a difference of aspect: While the botanist is interested in *limits* inherent to the "continuous multiplication of things once created ", the flower-lover concentrates on quite the opposite, namely change and variety – the " infinite sport of nature without end" – and the *means to effect* these, notably by gardening technologies.[40]

That this is not just nit-picking reasoning to reach some social distinction for botanists, but has important consequences on the level of theorising can be confirmed by a glance at the content of seventeenth and early eighteenth century horticultural literature: Far away from expounding something like "laws of generation" it indulges in the multifarious means of effecting the

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[36] Linnaeus (1737a), § 259, p. 152-155: "Primaria causa, cur nomina specifica Antecessorum fallacia evaserint, sola in eo consistit, quod partes & notas naturales, ac certas, a ludicris distinguere recusarint. Cum autem assumserint omnes notas, accidentales & naturales indifferenter, indeque constituerint ob minimum notam, novam speciem, orta fuit tanta confusio, tanta nominum barbaries, tanta specierum falsarum accumulatio, ut facilius stabulum Augias purgare, quam Botanicen. [...].
Certe si omnis nota indifferens novam constituat speciem, nulli mortalium Botanici Sapientiores & acutiores ANTHOPHILIS, qui in solis *Tulipis, Primulis, Anemonibus, Narcissis, Hyacinthis* omni anno aliquot millia Botanicis ignotas, novas proinde, species ostendunt curiosis. Desistebat ab opere Creationis Omnipotens Conditor die septima, nec nova creatio omni die, sed continuata multiplicatio creatorum. Hominem creavit unicum, dictiante S. Scriptura: at si minima nota sufficiat, vel mille hominum species hodie prostant; prostant enim capillis albis, rubris, nigris, canis; facie alba, rosea, fusca, nigra; naso erecto, brevi, inflexo, simo, aquilino; prostanbt gigantes, pygmæi, obesi, macilenti, erecti, incurvi, tophosi, claudi &c. &c. sed quis leviter ianus hos distinctas diceret species. En itaque assumamus notas certas, & inquiramus notas fallaces, quae seducunt, nec variant rem, [...].
Tournefortius Tulipas 93. (ubi una est) & Hyacinthis 63. (ubi duo sint) numerat, nec minus sæpe in aliis alii luxuriarunt."

[37] Ibid, § 306, p. 238: "Anthophilorum & Botanicorum in Varietatibus objecta eadem sunt, ea tamen cum differentia, ut Anthophilus incipiat scenam, ubi Botanicus definit; hic, dum lassus quasi, finem operi imponit; ille, vegetus struere incipit, ut astra petat."

"transmutation" of plants, like soil preparation, watering, application of heat and manure, grafting, transplantation etc. Thus we find Laurembergius setting out the following general principle in the first book of his *Horticultura* 1631:

> [...] for the prosperity and flourishing of gardens; for the growth and augmentation of fruits, flowers, and vegetables, we wish for two things: [...]: These are a benign sky and a fecund earth. The sky is the father of everything sown; the earth the mother.[41]

This is as far away as can be from the principles expounded in Linnaeus's species definition. And it is clear, that, with such principles, the transmutation, or degeneration, and the spontaneous generation of plants would make perfect sense. And even though doubts in transmutation should grow towards the turn to the eighteenth century;[42] and even though artificial pollination should more and more raise the interest of authors on gardening, the situation in horticultural literature seems to have remained basically the same up to the time of Linnaeus, i. e. artificial pollination should remain one among many means to meliorate plants, and it should basically be thought of in analogy to technological processes.[43] And still in 1773, we see that Joh. Chr. Fabricius, one of the more famous of Linnaeus's students, was able to announce similar principles as his teacher in a chapter on "Gartenbau":[44]

> Die unzähligen Abänderungen der Gewächse beobachtet der Gärtner. Wir verlangen die besten unter denselben, und man muß mehr auf die Cultur der Abänderung, als die Art selbst sehen. [...]. Die Ursachen dieser vielen Abänderungen untersucht der Gärtner nach dem Boden, dem Clima, der Cultur und vielleicht der Zeugung (generatio hybrida).

The distinction of horticulture as a basically technological discipline does of course not mean that the knowledge accumulated on the basis of horticultural practices was of no significance for Linnaeus's theory of (plant) reproduction. Quite the contrary is true: In the *Philosophia botanica* Linnaeus explicitely stated that "culture is the mother of so many varieties, and thus also the best mean of examining varieties."[45] After all, he was, as director of the Uppsala university garden, also

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38 Ibid, § 310, p. 245-246: "Species omnes Botanicorum eodem numero, quo hoc vel futuro tempore existent, ab Omnipotentis Creatoris manu profluxerunt: Anthophilorum autem a Speciebus (Botanicis dictis) omni die novæ & diversæ prognascuntur, & prognatae in priores tandem ruunt. Illis itaque impositi sunt limites a natura certi, ultra quos progredi nequeat; in his vero lusus infiniti naturae absque fine; Illorum species Sapientissima a Manu Omnipotentis, horum Varietates a Ludente natura, sub auspiciis præsertim Hortulanorum, prodiere. Hinc differentia inter Botanicum & Anthophilum maxima."

39 In his *Genera plantarum* Linnaeus even declared his dependance on Tournefort, by stating that he understood "no one but Tournefort and his school" (Linnaeus (1737b), § 11, [p. 6]).

40 Cf. Linnaeus (1739), which is discussed in detail in Müller-Wille (1999), pp. 151-155.

41 Laurembergius ([1631] o.J.), lib. I, cap. i, § 7, p. 38: "[...] ad hortorum prosperitatem, florentemq; constitutionem; ad fructum, florum, olerum felicem proventum & incrementa, duo adesse optamus [...]. Ea sunt Coelum benignum, & terra foecunda. Coelum satorum omnium Pater est. Terra mater." In the foreword it says in ragard to wine "tot genera, tot species, tot deliciae, quot regiones, quot oppida & urbes", something any wine *afficiando* would wholeheartedly agree to even today.

42 See, e. g., Sharrock (1660), pp. 28-32, who, however, concludes at one instance that "it was reason we should believe the report [on a transmutation] of good artists in matters of their own faculty". In Rudbeck jun. (1686), who was one of the teachers of Linnaeus, we find Laurembergius principles still expounded (p. 5) and spontaneous generation admitted (p. 8ff.). Rich material on the belief in "degeneration" till the end of the seventeenth century see Zirkle (1935), pp. 61-88.

very much himself involved in gardening.[46] Yet it shows, again, that something else had to enter the scene apart from the *mere production* of variety for the formation of his theory.[47]

4. Cabbage

> CABBAGE. "Baal (Rich.), gardener from Brainford, had collected an enormous amount of seeds from flowered cabbage [cauliflower?] in his garden and sold it to most of the gardeners living in the suburbs of London. But these, after having sown these seeds with care in fat earth, produced common, long-leafed cabbage, wherefore they lamented to have been betrayed and summoned the aforesaid Baal before the Westminster court, who was condemned by the decision of the judge not only to repay the price to them, but also to restore the waste of time and loss of land use." Raj. hist. I. p. 42. The deed is not to be ascribed to that gardener Baal, but to an impregnation of his better cabbage by the common cabbage. Therefore, if someone possesses that better cabbage, he should not let it flower on the same bed with another one, so that the better one is not fecundated with pollen from the lower and the lower one is generated from the seeds.[48]

This third example for empirical references in Linnaeus's *Sponsalia plantarum* also stems from horticulture, yet with a decisive, additional shift in comparison with the case of the tulips: The "criminal case" reported does not only encompass the local production of varieties (in which Baal seems to have been quite successful) but also their circulation. Its geographical localisation – *in suburbanis Londini* – is revealing in this respect: It was near this large city and – some decades earlier – near the cities of Holland that from the 1650ies onwards and due to population growth in the urban centers crop production changed from subsistence to commercial production, involving a separation of production and consumption and a consequent interposition of trade mechanisms.[49] For this trade – either in the products themselves, or in seeds as an important means of production – it was vital, of course, that the products exchanged did not change due to their transport from one locality to the other. Baals failure to guarantee this for his seed variety – he did notably not fail in the production of this variety as such – was responsible for his trial and – most probably – subsequent ruin.[50]

There is something else noteworthy about the reference to Baal's fate: As in the case of the Copenhagen Ethiopian discussed before, Linnaeus quotes from literature and adds an explanation

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43 Thus we see Richard Bradley, one of the "fathers" of plant sexuality and probably the source for Linnaeus's report on the "delightful experiment" with tulips (cf. Roberts ([1929] 1965), pp. 65/66), speak of fertilisation as a "mixing of qualities" and a possible source of "adulteration". Well into the 17th century, plant sexuality was generally denied, and even the fig, on which articial pollination had been used since Babylonian times, was regarded either as exceptional or as only analogically sexual (thus Laurembergius; cf. Prest (1988), pp. 81-84).

44 Fabricius (1773), p. 45.

45 Linnaeus (1751), § 316, p. 247: "Cultura tot Varietatum mater, optima quoque Varietatum examinatrix est."

46 Accordingly, he knew the horticultural literature very well; see Stearn (1976).

47 A close study of seventeenth and early eigteenth century literature on gardening and animal husbandry is, I believe, the great lacunae in the history of biology, which I, for the purposes of this paper, could of course not fill. The two most important publications on this topic are Zirkle (1935) and Roberts ([1929] 1965), which, however, because of their interest in the prehistory of Mendelism, exclusively focus on early accounts of "hybridisation". Henrey (1975), though voluminous and highly informative, rather serves bibliographical puposes.

to the case in question that rests on (and thus supposedly validates) his own theory of (plant) reproduction. And again, we can observe that this addition is contrary to the context of the original source: The quote is from a book John Ray published in 1686 and which bore the monstrous title *Historia plantarum Species hactenus editas aliasque insuper multas noviter inventas & descriptas complectens : in qua agitur primò De Plantis in genere, Earúmque Partibus, Accidentibus & Differentiis; Deinde Genera omnia tum summa tum subalterna ad species usque infimas, Notis suis certis & characteristicis definita, Methodo Naturae vestigiis insistente disponuntur, Species singulae accurate describuntur, obscura illustrantur, omissa supplentur, superflua resecantur, Synonyma necessaria adjiciuntur; Vires denique & usus recepti compendiò traduntur* (not surprisingly Linnaeus should refer to this work as one of the few "universal" plant histories in his *Bibliotheca botanica*[51]). This title already indicates, that *Brassica florida* belonged to a context much more systematic than that of the Copenhagen Ethiopian, and it occupied a central position within this context: Other than Linnaeus, Ray added the case of *Brassica florida* under the heading "About the transmutation of species among plants (*De Specierum in Plantis transmutatione*)" as a problematic case to a chapter, which discusses the "so called specific differences of plants (De specifica (ut vocant) Plantarum differentia)", thus revealing the *translation of plants* as a relevant field of empirical evidence for his discussion of "specific differences". Interestingly, a central passage of this discussion reveals some close resemblances to Linnaeus species definition:

> As, namely, the difference in sex in animals is not enough to argue for a difference in species, because both sexes originate from the same kind of seed and not rarely from the same parents, although they differ from each other in many and insignificant properties; [...]: so, also, there is no surer sign for a specific conformity than that plants originate from the same seed, be it individually or specifically. For what differs in species perpetually serves its species and not does this [species] originate from that seed [of another species] or vice versa.
>
> Therefore I propose not to hold for different species of plants those that differ by the colour [...] of the flower alone. [...].
>
> [Because these varieties] can be brought about by art and display, not less than by repeated translation from one place to the other and by irrigation with water tinged with some colour. [...] Laurembergius, a worthy and truthful man, wrote in his Horticultura that he experienced [this] often in pinks [...].[52]

48 Linnaeus ([1746] 1749), p. 370: "BRASSICA. *Baal* (Rich.) hortulanus Brainfordensis, ingentem copiam seminis Brassicæ floridæ in horto suo collectam, hortulanis quam plurimis in suburbanis Londini degentibus vendidit; At hi cum summa cura eadem semina terræ pingui commiserunt, brassicas longifolias vulgares ipsis produxere, quare se fraudatos queruntur, & prædicto Baal litem intendunt in foro Vestmonasteriensi, qui ex sententia judicum condemnatus est, non solum ut ipsis pecunias restitueret, sed jacturam temporis, & amissum terræ usum fructum resarciret. Raj. hist. I. p. 42. Facinus hoc hortulano Baal non adscribendum est, sed impræagnationi Brassicæ ejus optimæ a Brassica vulgari factæ. Quare si quis Brassicam possideat optimam, eandem cum alia in eadem areola florescere non sinat, ne præstantior vilioris polline fecundutur, & ex seminibus vilior generetur."

49 Slicher van Bath (1963), pp. 14/15, Grigg (1982), pp. 102ff. Grigg also notes a steep rise in the number of books published on agriculture in the sebventeenth century (ibid., p. 159). The distinction of the spheres of production/consumption and circulation is reflected in Sharrock (1660), p.3: "The end of the Artist is to Propagate and Improve".

50 On the emergence of seed trade see Webber (1968).

51 Cf. Linnaeus (1751), § 12, p. 10.

In contrast to Linnaeus's axiomatic species definition this formulation of a criterion for "specific conformity (*convenientia specifica*)" reveals its experiential basis and a peculiar shift in regard to it: While Ray's formulation already foreshadows the three "absences" we observed in Linnaeus – absence of substance, physiology and environment[53]– Laurembergius used the experiences Ray drew upon in quite the opposite direction:

> The diverse regions and parts of the earth are imbued with diverse liquids of diverse properties, with which the plant adorns itself, and as it draws new food who wonders that it also acquires a new nature because of the subordination and mutual proportion between that which nourishes and that which is nourished? Thus we see white flowers change into red, yellow, blue on dousing with liquid tinged with these colours, which attracted by the roots bring a similar shape to the flowers.[54]

Behind this peculiar shift lay two decades of botanical activity, in which Ray concentrated on two projects: cataloguing plant species both indigenous *and* exotic to England - with the *Catalogus plantarum circa Cantabrigiam nascentium* (1660) and the *Methodus plantarum nova* (1682) demarkating this project – and experimental studies into plant embryology and physiology. The aim of the first project was announced in the 1660 Catalogus as asking "by which similarity and by which characters [any unknown plant] coincides with its congeners (*ex similitudine, & notis quibus cum congeneribus conveniret*)"[55]. The experiments, carried out in collaboration with Francis Willoughby and Martin Lister, regarded the "motion of sap in trees" and operated by "bleeding" various trees to determine the flow directions of the "sap" under various conditions.[56] Parallel to that, Ray studied the structure of the seed plant, reaching the distinction of mono- and dicotyledons.[57]

Both cataloguing and experimenting on plants depended on a highly specific locality: the botanic garden, in which on the one hand plants from all over the world were collected and

[52] Ray (1686), lib. I, cap. xx, p. 40: "Sicut enim in Animalibus sexuum distnctio non sufficit ad speciei diviersitatem arguendam, quia sexusa uterque ex eodfem speciei semine, eisdémque non rarò parentibus orìtur, quamvis multis & insignibus Accidentibus inter se differant; [...]: sic pariter in plantis convenientiæ specificæ non aliud certius indicium est quàm ex semine ajusdem plantæ seu in specie seu in individuo oriri. nam quæ specie differunt speciem suam perpetu' servant, neque hæc ab illius semine oritur, aut vice versa.
Hinc pro distinctis plantarum seciebus non habendas censeo,
1. Quæ solo floris colore [...] differunt. [...]
Denique arte & mangonio induci possunt, nimirum translatione iterata de loco in locum, & irrigitaione aquà colore aliquo imbutà. Nam P. Laurembergius, vir fide dignus, Horticult. cap. 28. Sect. 3. se in Caryophyllis sæpius expertum scribit [...]."

[53] Ray ended his unpublished "discourse on the specific differences of plants" with the following words, which clearly foreshadowed Linnaeus's species definition: "By this way of sowing ["in rich soil"] may new varieties of flowers and fruits be still produced ad infinitum, which affords me with another argument to prove them not specifically distinct; the number of species being in nature certain and determinate, as is generally acknowledged by philosophers and might be proved also by divine authority, God having finished his works of creation, that is, consummated the number of species in six days" (Ray 1674), p. 173.

[54] Laurembergius ([1631] o.J.), cap. XIII, § vi, p. 77: "Diversae autem regiones & telluris partes diversis sunt imbutae humoribus, diversis proporietatibus, & novo cibo ali assuscit, quid mirum si & novam acquirat naturam, propter illam quae est inter alitum & alens subordinatium & proportionem mutuam? Ita videmus flosculos albos permutari in rubros, flavos, ceruleos, affusione humoris his coloribus imbuti; qui per radices attractus similem florem ideam conciliat."

[55] Ray (1660), p. 5.