



---

The Early History of the Idea of the Inheritance of Acquired Characters and of Pangenesis

Author(s): Conway Zirkle

Source: *Transactions of the American Philosophical Society*, Vol. 35, No. 2 (Jan., 1946), pp. 91-151

Published by: [American Philosophical Society](#)

Stable URL: <http://www.jstor.org/stable/1005592>

Accessed: 10-04-2015 00:38 UTC

---

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at <http://www.jstor.org/page/info/about/policies/terms.jsp>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.



*American Philosophical Society* is collaborating with JSTOR to digitize, preserve and extend access to *Transactions of the American Philosophical Society*.

<http://www.jstor.org>

TRANSACTIONS  
OF THE  
AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA  
FOR PROMOTING USEFUL KNOWLEDGE

---

NEW SERIES—VOLUME XXXV, PART II

---

THE EARLY HISTORY OF THE IDEA OF THE INHERITANCE  
OF ACQUIRED CHARACTERS AND OF PANGENESIS

CONWAY ZIRKLE  
*Professor of Botany  
University of Pennsylvania*

---

THE AMERICAN PHILOSOPHICAL SOCIETY  
INDEPENDENCE SQUARE  
PHILADELPHIA 6

JANUARY, 1946

COMMITTEE ON PUBLICATIONS

JACOB R. SCHRAMM, *Chairman*

WILLIAM B. DINSMOOR

LUTHER P. EISENHART

HENRY C. LANCASTER

WILLIAM E. LINGELBACH

ARTHUR D. NOCK

ERNEST M. PATTERSON

ADOLPH H. SCHULTZ

ROBERT L. SCHUYLER

GEORGE G. SIMPSON

HUGH S. TAYLOR

---

LUTHER P. EISENHART, *Editor*

---

LANCASTER PRESS, INC., LANCASTER, PA.

# THE EARLY HISTORY OF THE IDEA OF THE INHERITANCE OF ACQUIRED CHARACTERS AND OF PANGENESIS

CONWAY ZIRKLE

## CONTENTS

	PAGE
Introduction .....	91
I. The inheritance of acquired characters .....	93
1. From the beginning to the sixteenth century .....	93
2. Sixteenth century records .....	97
3. Seventeenth century records .....	100
4. Eighteenth century records .....	105
5. Some nineteenth century records to the time of Charles Darwin .....	116
II. Pangenesis .....	119
1. Records from the beginning to the thirteenth century .....	120
2. Thirteenth century records .....	124
3. Fourteenth and fifteenth century records .....	127
4. Sixteenth century records .....	128
5. Seventeenth century records .....	134
6. Eighteenth century records .....	139
7. Nineteenth century records to the time of Charles Darwin..	144
Conclusion .....	145
References .....	148
Index .....	151

## INTRODUCTION

In 1802 the CHEVALIER DE LAMARCK published his *Recherches sur l'organisation des corps vivants*. Here, for the first time, he sketched out his doctrine of evolution. Seven years later, in his *Philosophie zoologique*, he published his fully developed theory, and, although he often restated his views, he never had occasion to alter them. Perhaps the most condensed statement of his idea is to be found in his *Histoire naturelle*, from which the following translation of his four well-known "laws" is taken (as quoted by Osborn, 1894).

1. Life by its internal forces tends continually to increase the volume of every body that possesses it, as well as to increase the size of all its parts, up to a limit which it brings about.

2. The production of a new organ or part results from a need or want, which continues to be felt, and from a new movement which this need initiates and causes to continue.

3. The development of organs and their force or power are always in direct relation to the employment of these organs.

4. All that has been acquired or altered in the organization of individuals during their life is preserved by generation, and transmitted to new individuals which proceed from those which have undergone these changes.

The logical inference from these "laws," of course, is that species are not constant units but change as the occasion demands. This is stated in the *Philosophie zoologique* (translated by Hugh Elliot, London, 1914, p. 126) as follows:

My individual conclusion: Nature has produced all the species of animals in succession, beginning with the most imperfect or simplest, and ending with the most perfect, so as to create a gradually increasing complexity in their organization; these animals have spread at large throughout all the habitable regions of the globe, and every species has derived from its environment those habits that we find in it and the structural modifications which observation shows us.

What Lamarck really did was to accept the hypothesis that acquired characters were heritable, a notion which had been held almost universally for well over two thousand years and which his contemporaries accepted as a matter of course, and to assume that the results of such inheritance were cumulative from generation to generation, thus producing, in time, new species. His individual contribution to biological theory consisted in his application to the problem of the origin

of species of the view that acquired characters were inherited and in showing that evolution could be inferred logically from the accepted biological hypotheses. He would doubtless have been greatly astonished to learn that a belief in the inheritance of acquired characters is now labeled "Lamarckian," although he would almost certainly have felt flattered if evolution itself had been so designated.

A belief in the inheritance of acquired characters arises naturally from an attempt to connect two well established observations. First, the easily observed fact that both animals and plants are modified by environmental changes and that these modifications are, within limits, adaptive. Indeed, unadaptive organisms could hardly be expected to survive the normal fluctuations of terrestrial living conditions. Second, that offspring do in general resemble their parents. Anyone who knew these two facts but who did not have a precise knowledge of the distinction between what we now call congenital and environmentally induced characteristics would be apt to accept the inheritance of acquired characters almost without question. Actually, the very words we use today show the past and, in part, the present confusion of ideas. We now know that, literally, all characters are both acquired and hereditary. Our modern denial of the inheritance of acquired characters implies a strictly limited meaning of the phrase. When we speak of such characters we really mean acquired deviations<sup>1</sup> or acquired variations caused by abnormal environmental conditions. Popular beliefs, however, are rarely conditioned by critical scientific evidence. Words are generally taken at their face value and ideas which are superficially reasonable are not checked by the results of carefully devised experiments. Thus the inheritance of acquired characters had been generally accepted and evidence for its widespread popularity is not wanting. We find it firmly entrenched in bronze-age myths and in the popular beliefs of today. The *Just so stories* of Rudyard Kipling are pointless without it.

Thus, when Lamarck sought to explain the great diversity of species through the inheritance of acquired characters, he was merely applying a universally accepted, reasonable, and orthodox doctrine to a problem which interested his contemporaries. The circumstances would seem to favor the general acceptance of his theories. He was most unfortunate, however, when he attempted to cite data to substantiate his views or when he used the inheritance of acquired characters to explain the development of particular organs. In the following passages he was simply asking for ridicule. From p. 119-120, ed. cited:

We find in the same way that the bird of the water-side which does not like swimming and yet is in need of going

<sup>1</sup> When such abnormalities are due to germinal changes their heritability has been proved, but when they are environmental in origin all the evidence we have indicates the contrary.

to the water's edge to secure its prey, is continually liable to sink in the mud. Now this bird tries to act in such a way that its body should not be immersed in the liquid, and hence makes its best efforts to stretch and lengthen its legs. The long-established habit acquired by this bird and all its race of continually stretching and lengthening its legs, results in the individuals of this race becoming raised as though on stilts, and gradually obtaining long, bare legs, denuded of feathers up to the thighs and often higher still.

From *Système des animaux sans vertèbres*, p. 14:

We note again that this same bird wants to fish without wetting its body, and is thus obliged to make continual efforts to lengthen its neck. Now these habitual efforts in this individual and its race must have resulted in the course of time in a remarkable lengthening, as indeed we actually find in the long necks of all water-side birds.

If some swimming birds like the swan and goose have short legs and yet a very long neck, the reason is that these birds while moving about on the water acquire the habit of plunging their head as deeply as they can into it in order to get the aquatic larvae and various animals on which they feed; whereas they make no effort to lengthen their legs.

From p. 122.

Since ruminants can only use their feet for support and have little strength in their jaws, which only obtain exercise by cutting and browsing on the grass, they can only fight by blows with their heads, attacking one another with their crowns.

In the frequent fits of anger to which the males especially are subject, the efforts of their inner feeling cause the fluids to flow more strongly towards that part of their head; in some there is hence deposited a secretion of horny matter, and in others of bony matter mixed with horny matter, which gives rise to solid protuberances, thus we have the origin of horns and antlers, with which the head of most of these animals is armed.

It is interesting to observe the result of habit in the peculiar shape and size of the giraffe (*Camelo-pardalis*): this animal's fore-legs have become longer than its hind legs, and that its neck is lengthened to such a degree that the giraffe, without standing up on its hind legs, attains a height of six metres (nearly 20 feet).

The story of how the elephant's child got its trunk, however, is not Lamarck's but Kipling's.

The question as to the mechanism by which acquired characters were transmitted from one generation to the next was bound to arise as soon as philosophical speculation got around to the subject. It is interesting to note that only one real hypothesis was ever advanced. Of course, there were minor differences in the explanations offered by different philosophers, but all of them were but minor variants of what CHARLES DARWIN called his "provisional hypothesis of pangenesis." As Darwin described pangenesis in perhaps its most highly developed form, a direct quotation from his speculation may not be amiss. From his *The variation of animals and plants under domestication*, New York, 1868:

. . . But besides this means of increase I assume that cells before the conversion into completely passive or "form-material," throw off minute granules or atoms, which circulate freely throughout the system, and when

supplied with proper nutriment multiply by self-division, subsequently becoming developed into cells like those from which they were derived. These granules for the sake of distinctness may be called cell-granules or, as the cellular theory is not fully established, simply gemmules. They are supposed to be transmitted from the parents to the offspring and are generally developed in the generation which immediately succeeds, but often transmitted in a dormant state during many generations and are then developed. Their development is supposed to depend on their union with other partially developed cells or gemmules which precede them in the regular course of growth. Why I use the term union will be seen when we discuss the direct action of pollen on the tissues of the mother plant. Gemmules are supposed to be thrown off by every cell or unit, not only during the adult state, but during all the stages of development. Lastly, I assume that the gemmules in their dormant state have a mutual affinity for each other, leading to aggregation either into buds or into sexual elements. Hence, strictly, it is not the reproductive elements, nor the buds, which generate new organisms, but the cells themselves throughout the body. These assumptions constitute the provisional hypothesis which I have called Pangenesis.

Now the doctrine of the inheritance of acquired characters is so intimately connected with the hypothetical mechanism which explained its occurrence that neither idea can be given an adequate historical treatment alone. They must be considered together as parts of a greater whole. However, in the actual historical records they are generally described separately and at times they are even developed independently, particularly by individuals who never quite grasped the whole idea. There are also whole groups who indorsed only one aspect or the other of the entire problem. For example, the sixteenth-century physicians, as a whole, described pangenesis and not the inheritance of acquired characters, while the eighteenth-century anthropologists did the reverse. Thus a certain continuity is secured by presenting the descriptions in two series, except when they occur in the same passage. Such passages will be included in chronological order in part I of this paper, "Inheritance of Acquired Characters." In part II, "Pangenesis," the passages which have been quoted in part I will merely be listed in their proper chronological position in the series of citations describing pangenesis.

## I. THE INHERITANCE OF ACQUIRED CHARACTERS

### 1. FROM THE BEGINNING TO THE SIXTEENTH CENTURY

Perhaps the earliest precise account of an acquired character becoming hereditary is to be found in the story of Phaëthon. Phaëthon, the half-human son of Apollo, inveigled his father into allowing him to drive the chariot of the sun across the sky. The horses, who drew the chariot, ran away and carried the sun so close to the land of the Ethiopians that the inhabitants were scorched. Their blood was drawn by the heat so quickly to the surface of their bodies that they became

black and this character has been passed on to their descendants. Today, the Ethiopians are still black.

Traces of a belief in the inheritance of acquired characters are also found in the Hebrew scriptures, although at first glance it would appear to be somewhat far-fetched for us to consider the persisting effects of Adam's sin as a genetical problem. However, when we examine the whole picture this appears to be the case. Sin was thought to be debilitating, and debilitated parents supposedly could not beget normal, healthy children. This gives us a possible physical explanation of "visiting the iniquity of the fathers upon the children and the children's children unto the third and fourth generation" (Exodus 34:7; 20:5). Weakened bodies merely begat defective offspring.<sup>2</sup> Later such inheritance was expressly denied, but the denial was based exclusively upon moral grounds.

From the Book of Jeremiah, Chapter 31:

29. In those days they shall say no more, The fathers have eaten a sour grape and the children's teeth are set on edge.

30. But everyone shall die for his own iniquity; every man that eateth the sour grape, his teeth shall be set on edge.

And again in Ezekiel (Chapter 18):

2. What mean ye that ye use this proverb concerning the land of Israel, saying The fathers have eaten sour grapes and the children's teeth are set on edge?

3. As I live, saith the Lord God, ye shall not have occasion any more to use this proverb in Israel.

Yet in spite of this denial, the inheritance of original sin remained a definite theological problem which the Church had to face.<sup>3</sup>

When we reach the ancient Greeks, we find the whole idea of the inheritance of acquired characters and of pangenesis completely developed. HIPPOCRATES (*ca.* 400 B.C.) in his *Airs, waters, places* XIV (tr. by Frances Adams) uses the accepted views of his time to account for the physical divergence of the "Long-heads."

I will begin with the Longheads. There is no other race at all with heads like theirs. Originally custom was chiefly responsible for the length of the head, but now custom is reinforced by nature. Those that have the longest heads they consider the noblest, and their custom is as follows. As soon as a child is born they remodel its

<sup>2</sup> See quotation from Roger Bacon, page 96.

<sup>3</sup> St. Augustine, *Marriage and concupiscence* (tr. by Peter Holmes), Bk. I, Ch. 37: That, however, which in the case of a regenerate parent, as in the seed of a pure olive, is conceived without any guilt, which has been remitted, is still no doubt retained in the case of the offspring, which is yet unregenerate, as in the wild olive, with all its guilt, until there also it be remitted by the self-same grace. When Adam sinned, he was changed from that pure olive, which had no such corrupt seed whence should spring the bitter issue of the wild olive, into a wild olive tree; and, inasmuch as his sin was so great, that by it his nature became commensurately changed for the worse, he converted the entire race of man into a wild olive stock. (The same idea is also expressed in Ch. 21.)

head with their hands, while it is still soft and the body tender, and force it to increase in length by applying bandages and suitable appliances, which spoil the roundness of the head and increase its length. Custom originally so acted that through force such a nature came into being; but as time went on the process became natural, so that custom no longer exercised compulsion. For the seed comes from all parts of the body, healthy seed from healthy parts, diseased seed from diseased parts. If, therefore, bald parents for the most part beget bald children, grey-eyed parents grey-eyed children, squinting parents squinting children, and so on with other physical peculiarities, what prevents a long-headed parent having a long-headed child? At the present time long-headedness is less common than it was, for owing to intercourse with other men the custom is less prevalent.

In two other passages (quoted on page 121) Hippocrates describes pangenesis and attempts to give the physical basis for the inheritance of disease.

In spite of the fact that ARISTOTLE (384–321 B.C.) denied the possibility of pangenesis (page 121), he accepted implicitly the inheritance of acquired characters. It would be difficult to find a clearer anticipation of Lamarck's views than in the two following passages. From *Generation of animals* I: 17 (translated by Platt, 1910):

And these opinions are plausibly supported by such evidences as that children are born with a likeness to their parents, not only in congenital but also in acquired characteristics; for before now when the parents have had scars, the children have been born with a mark in the form of a scar in the same place, and there was a case at Chalcedon where the father had a brand on his arm and the letter was marked on the child, only confused and not clearly articulated.

From *History of animals* VIII: 6 (translated by Thompson, 1910):

From deformed parents come deformed children, lame from lame and blind from blind, and speaking generally, children often inherit anything peculiar to their parents and are born with similar marks such as pimples and scars. Such things have been known to have been handed down through three generations; for instance, a certain man had a mark on his arm which his son did not possess, but his grandson had it in the same spot though not very distinct.

Such cases, however, are few; for the children of cripples are mostly sound, and there is no hard and fast rule regarding them.

Thus, Aristotle did not believe that mutilations were always inherited, an idea which he also expressed in *Generations of animals* I: 18:

If mutilated young are born of mutilated parents, it is for the same reason as that for which they are like them. And the young of mutilated parents are not always mutilated, just as they are not always like the parents; the cause of this must be inquired into later, for this problem is the same as that.

Another Grecian philosopher, ANTIGONUS (285–247 B.C.), probably accepted the inheritance of acquired characters as is shown by a casual reference in his

*Historiarum mirabilium* (Ch. 121, ed. of Leipzig, 1791) to those born defective.

Indeed blind and dumb are born from the blind and dumb and not a few are born with a scar at birth.

On the other hand, LUCRETIUS (*ca.* 99–55 B.C.) did not believe that acquired modification could be passed on to the following generations. In his great poem, *De rerum natura*, he states (tr. by Thomas Jackson):

. . . For if the first beginnings of things could be changed being in any way overmastered, it would also now remain uncertain what could arise and what could not, in a word in what way the power of each thing is limited and its deep-set boundary mark, nor could the generations so often repeat after their kind the nature, manners, living and movement of their parents.

This denial is interesting in view of the fact that Lucretius believed in pangenesis and in a modified form of the continuity of the germ plasma (page 122).

The geographer, STRABO (7 B.C.), was faced with the problem of explaining the black skin of the Ethiopians. He used the stock explanation. From Bk. XV, Ch. 1, § 24:

And already in the womb, children, by seminal impregnation, become like their parents in color; for congenital affections and other similarities are also thus explained.

PLINY (A.D. 77) was not one to miss the recording of a belief so widespread as that of the inheritance of acquired characters. From Bk. VII, Ch. 11, p. 160–161 (Holland's translation, *The historie of the world*):

Over and besides it is commonly seene, that children be not alwaies answerable to the parents in every respect: for of perfect fathers and mothers who have all their limmes, there are begotten children unperfect and wanting some members: and contrariwise, parents there are maimed and defective in some parts, and who nevertheless engender children that are sound and entire, lind with all they should have. It is seene also, that infants are at a default of such parts as their parents misse. Yea, and they carie often-times certain markes, moles, blemishes, and skarres, of their fathers and mothers, as like as may be. Among the people called Dakes, the children usually carrie the markes imprinted in their armes, often from whom they are descended, even to the fourth generation.

PLUTARCH (46–135) was noncommittal as to whether or not acquired characters were inherited. We owe to his records, however, our knowledge that Democritus and the Stoics believed in pangenesis. He discussed in detail the ethics of punishing children for the sins of their fathers. From *Concerning such whom the Gods are slow to punish* (tr. by John Philips), § 12:

. . . Now, as to what we have further to say, we find that Euripides delivers his mind freely, and censures the Gods for imputing the transgressions of forefathers unto their offspring. And I am apt to believe that even they who are most silent among us do the like. For if the offenders themselves have already received their reward, then there is no reason why the innocent should be punished, since it is not equal to punish even criminals twice

for the same act. But if remiss and careless, the Gods, omitting opportunely to inflict their penalties upon the wicked, send down their tardy rigor on the blameless, they do not well to repair their defective slowness by injustice.

SUETONIUS (first half of second century) recorded a popular legend as serious history. The tale, however, illustrates how widespread was the belief in the inheritance of acquired characters. From *Nero*, Bk. I, Ch. 1 (tr. by Holland):

The Ahenobarbi have as founder of their race and the origin of their surname Lucius Domitius, to whom, as he was returning from the country, there once appeared twin youths of more than mortal majesty, so it is said, and bade him to carry to the senate and people the news of a victory which was as yet unknown. [The youths were Castor and Pollux, and the victory that at Lake Regillus, in 498 B.C., according to the traditional chronology.] And as a token of their divinity it is said that they stroked his cheeks and turned his black beard to a ruddy hue, like that of bronze. This sign was perpetuated in his descendants, a great part of whom had red beards. . . . It seems to me worth while to give an account of several members of this family, to show more clearly that though Nero degenerated from the good qualities of his ancestors, he yet reproduced the vices of each of them, as if transmitted to him by natural inheritance.

We can also assume that, at about this time, GALEN (130–220) accepted the inheritance of acquired characters, as he quoted with approval a passage of Hippocrates which described pangenesis and the transmission of defects from one generation to another (p. 121). Also the great polyhistor, GAIUS JULIUS SOLINUS (*ca.* 275–300), seemed to believe in such inheritance, as he described how peculiarities ran in families (ed. of Salmasius, Leipzig, 1777, p. 25). Another record, likewise far from precise, is to be found in *Quaestiones ad Antiochum*, falsely attributed to ST. ATHANASIUS OF ALEXANDRIA (296–373) (in bibliography included in St. Athanasius' *Opera Omnia*). In this passage the climate is pictured as affecting directly the human populations. All human beings were originally assumed to have come from a common source and the divergent stocks were supposed (tacitly) to show the cumulative effects of their environments. From *Quaest.* 123:

As the nature of things testifies and teaches, we see that the hot element arises from the east; and, a witness of this fact are the Indians who come from the east more than all others (people); and a witness to this fact are their bodies which the intense heat makes black. For God in the beginning did not make man black. Consequently, the cadavers of the dead, having been exposed to the sun, become black and burned. For this reason the Ethiopians on account of the great and intensive heat are not able to drink much wine: but the strong and boiling heat renders them very irritable and violent and also more inclined to fornication. Now we have said how these things from the east occur, so we shall say the reverse about the west. For this part is cold, it is the mother and the producer of a cold element and a cold night. Hence its inhabitants have bodies whiter than all other peoples, and they readily drink much wine.

On the other hand the historian, JUSTINUS (*ca.* 400), was quite precise in a story he told (Bk. XV, Ch. 4, tr. by G. Turnbull):

His mother *Laodice* being married to *Antiochus*, a famous Commander in *Philip's* Army, dreamt that *Apollo* got her with child, and by way of Reward for the Enjoyment of her person gave her a Ring, with an Anchor engraved in the Stone of it, which she was commanded to give her son, whom she should be delivered of. . . . The token of his strange Original continued in his posterity, for his Sons and Grandsons wore the Resemblance of an Anchor in their thighs, the distinguishing Mark of their Family.

Following Justinus there is a gap of over eight hundred years in our records. Doubtless, during this time, the inheritance of acquired characters was accepted generally, for the basic philosophy of this period merely followed the older classical concepts. The Arabs, Byzantines, and Latins all relied to a greater or lesser extent upon the older Grecian speculations, and, as we have seen, the Greeks believed in this type of inheritance. When the writings of this period have been searched adequately and their biological contents made available to modern scientists, we may expect this gap to be closed somewhat. We do have records of pangenesis dating from this time, very definite ones from St. Isidore of Seville (622) and from Ibn Sina (979–1037), and a very ambiguous one from Michael Psellus (1017–1078).

In the remarkable thirteenth century our records grow voluminous. Pangenesis was described by Bartholomew the Englishman, William of Auvergne, St. Thomas Aquinas, St. Albertus Magnus, Vincent of Beauvais, and Roger Bacon. The inheritance of acquired characters was accepted by St. Thomas and Roger Bacon. Apparently St. Albert thought that mutilations were inherited at times, but such inheritance was denied by Vincent.

ST. THOMAS (*ca.* 1256) wrote a 4000-word article on pangenesis (p. 125) in his *Commentum in quatuor libros sententiarum Magistri Petri Lombardi*. In *Summa theologica* (Bk. II, *Quaest.* 81, Art. 1) he described the inheritance, not transmission, of disease:

. . . thus a leper may beget a leper, or a gouty man may be the father of a gouty son, on account of some seminal corruption, although this corruption is not leprousy or gout. . . .

But all these explanations are insufficient. Because, granted that some bodily defects are transmitted by way of origin from parent to child, and granted that even some defects of the soul are transmitted in consequence, on account of a defect in the bodily habit, as in the case of idiots begetting idiots; nevertheless the fact of having a defect, by way of origin seems to exclude the notion of guilt, which is essentially something voluntary.

St. Thomas was greatly concerned with the theological aspects of original sin and he denied the inheritance of sin on the grounds that, stated in our modern patois, sin is functional, not structural. From *Contra Gentiles*, Bk. IV, Ch. 51:



More amply: Man generates a likeness to himself in kind. In those things, then, which do not pertain to the generation of the form, the son need not be made like unto the parents. Sin cannot pertain to a part of the form because sin is not of those things which are according to nature but rather a corruption of the natural order. It is accordingly unnecessary that from the first sinner other sinners be produced.

Besides, children are made more similar to the nearest in the family line than to remote kindred. It happens, now that the nearest are without sin and in the process of generation no sin is committed. Hence not all are born sinners on account of the sin of the first parent.

However, since original sin was an admitted fact, St. Thomas could not let the matter rest here. In *Commentum . . . sententiarum . . . Petri Lombardi* (Bk. II, Dist. 30, *Quaest.* 1, Art. 2), he discussed the matter further:

Thus, then, it must be said that the defect of that original righteousness which was conferred on man at his creation befell through the will of man. And just as that natural gift was and would have been propagated throughout his whole nature—as long as man persisted in righteousness—so the deprivation of that good was carried throughout his whole nature like a deprivation and vice of his nature.

And later in the same passage:

To the third it must be said that original sin is not traduced through the traduction of its subject, which is the rational soul, but through the traduction of the semen. Because from the infection of the father's soul through sin, there follows also a disorder in the body at the departure of the order which its initial nature earlier received. So also from that semen a body is generated which is destitute of such order. Hence also the soul which is infused in such a body contracts the disorder of the fault from the very fact that the form is produced from this sort of body; since the execution was proportioned by something capable of perfecting. Just as on account of some corruption of the semen there occurs not only a defect in the body of the offspring generated from that semen, as leprosy, gout, or some such disease, but also a defect in the soul, as is manifest in those who from birth are naturally stolid.

To the fourth it must be said that the semen has not in itself the guilt-infection in *actu* but has it in *virtute*. Just as it is evident that from the leprous semen is generated a leprous child, although in the semen itself there is no leprosy in *actu*. For there is in the semen some defective force (*virtus deficiens*) through whose defect occurs the leprous defect in the offspring. Similarly, from the fact itself that in the semen is such a disposition which is deprived of that impassiveness and orderliness for the soul that the human body had in its first state, it follows that in the offspring, which is susceptible of original sin, the original sin be effected actually.

To the fifth it must be said that the soul is not infected through the infection of the body, as if the body were active over the soul, but through a certain agreement of one with the other: because the form is received in the material according to the condition of the material itself, as all that is in the second is in it by way of the receiver. And from the very fact that the body is deprived of that force by which it was perfectly subject to the soul, it follows also that the soul lacks that force by which it rules the body perfectly subject. The fault of such a defect of original righteousness is nature's, just as it is considered due to the will of some one having the nature, from whom his nature was traduced.

To the sixth it must be said that it would be unjust for a son to suffer punishment for the sin of his father unless the father's sin too crossed over into the son, so that now the son is punished not for the sin of his father but for his own sin.

ST. ALBERT'S remarks on the inheritance of mutilations occur in his *Animalia* (Bk. XV, Tr. 2, Ch. 3):

Besides, if what they say is true, the sons of those having defects will have imperfect and diminished members; always they will be with imperfection; and they will be incomplete and diminished in their members *and this defect we see to exist with our own eyes*. Nevertheless, in the following writings, we shall inquire the cause of both of these—namely, as much the cause of the similarity of children with their parents as the reason of the diminution of the members, which exists sometimes in parents and not in sons. For this question concerning the aforesaid accidents of both [similarity and diminution] is a common one.

VINCENT OF BEAUVAIS (1190–1264) in *Speculum naturale* denies the inheritance of mutilations as follows (Bk. XXXII, Ch. 11):

But you say, what though if some one with hands, feet, ears or a nose cut off should mate—the child which is thence born will lack those parts, I reply: nature avoiding imperfection labors to perfect every one in its kind. Therefore material gotten from other parts with a formative force perfects in the young what is lacking in the parent. The parts, of course, are not entirely dissimilar. Thus what it has taken from the bones of other members it converts into bones of the hands; flesh from one part into flesh of another part; nerves from one part into nerves of another, etc.

However, Vincent describes the inheritance of disease in a passage devoted to pangenesis (p. 124). ROGER BACON'S description of the inheritance of acquired characters is in his *Opus majus* written in 1268. He tried to account for the fact that men no longer lived to the alleged ripe old ages of the antediluvian Patriarchs. The Astrologers, whom he attacked, had claimed that the stars were at the most advantageous positions possible at the time of the creation, and that as time passed they moved to other and more unfavorable locations. As a result, human life was shortened—and the race became more and more "ill-starred." Bacon attempted to refute this claim by advancing what he thought was a more reasonable hypothesis to explain the cited facts, which, of course, he did not doubt. The following excerpt is from Part VI, Chapter XII, Example 2, as translated by R. B. Burke (1928):

Very rarely does it happen that anyone pays sufficient heed to the rules of health. No one does so in his youth, but sometimes one in three thousand thinks of these matters when he is old and approaching death, for at times he fears for himself and thinks of his health. But he cannot then apply a remedy because of his weakened powers and sense and his lack of experience. Therefore fathers are weakened and beget weak sons with a liability to premature death. Then by neglect of the rules of health the sons weaken themselves, and thus the son's son has a doubly weakened constitution, and in his turn weakens himself by a disregard of these rules. Thus a weakened constitution

passes from father to sons, until a final shortening of life has been reached as is the case in these days.

Not only is there this accidental cause, but there is also another, consisting in the disregard for morals. For sins weaken the powers of the soul, so that it is incompetent for the natural control of the body; and therefore the powers of the body are weakened and life is shortened. This weakening passes from father to son, and so on. Therefore owing to these two natural causes the longevity of man of necessity has not retained its natural course from the beginning; but for these two reasons the longevity of man has been shortened contrary to nature. Moreover, it has been proved that this excessive shortening of the span of life has been retarded in many cases, and longevity prolonged for many years by secret experiments. Many authors write on this topic. Wherefore this excessive shortening of life must be accidental, with a possible remedy.

We have, at present, but a single record of the inheritance of acquired characters from the fourteenth century although, when this period is better known, many such will undoubtedly be found. PIERRE BERSUIRE (d. 1362), the noted theologian, is responsible for our single description of this type of inheritance. He placed the origin of semen in the loins and thus did not indorse pangenesis, but he described the inheritance of a specific somatic modification in his version of the famous eel-viper hybridization. From his *Reductorium morale* (Bk. IX, Ch. 70):

According to Iorath and Ambrosius the eel never conceives from its own kind, but from a serpent, which it arouses and leads on by a hissing. Even though the serpent is poisonous in itself, nevertheless, *it belches forth its poison before a union of this kind, so that the eel conceives a non-poisonous off-spring, in nowise similar to the serpent but like unto itself.* But when the union has been completed the serpent returns to his poison again. The eel is the Blessed Virgin who does not conceive from her own kind, that is to say from man, but rather from God himself and the Holy Ghost, who then because of his venom of justice and severity could be called the serpent; but, to be sure, in this blessed union the serpent (i. e. God) has put aside his venom (i. e. all justice and severity) and so the eel (i. e. the Blessed Virgin) in nowise conceived a venomous or wicked offspring but rather a very kind and gentle one. Moreover, this serpent (i. e. God the Father) will on the day of Judgement take up the venom of his severity again, when he shall hand over the sinners to the eternal fires so that He who, in overlooking men's vices, now seems to lack the venom of severity, shall at that time appear poisonous to them when he punishes their vices.

## 2. SIXTEENTH CENTURY RECORDS

Our next description of the inheritance of acquired characters comes from the early sixteenth century. This does not mean, of course, that the view was not held generally in the fifteenth, but only that the available sources have not been investigated sufficiently. Late in the fifteenth century pangenesis was indorsed by a number of physicians and the first printed copies of the classical writings naturally contained numerous accounts of acquired characters being inherited. Thus the fifteenth century philosophers were certainly not

ignorant of the traditional belief and doubtless we shall sooner or later find documentary evidence of the fact that they accepted it. Our sixteenth century records are numerous.

The first of these records is in *The castel of helth* by SIR THOMAS ELYOT, published in 1539. Sir Thomas had to reconcile the accepted fact that the first human food consisted of fruit with the well founded observation that, in sixteenth-century England, fresh fruits and vegetables were definitely harmful. They could hardly be otherwise with the sanitary standards then in vogue, but Sir Thomas was innocent of any knowledge of sanitation. On the other hand, he knew that before sin came into the world, Adam and Eve were both vegetarians and healthy. From Bk. II, Ch. 7, 1:

For as moche as before that tyllage of corne was invented, and that devouring of fleshe and fyshe was of mankynde used, men undoubtedlye lived by, fruits, and Nature was therewith contended and satisfied, but by changing of the diete of our progenytours, there is caused to be in our bodies such alteration from nature, which was in men at the begynnynge, that nowe all frutes generally are noyfull to manne, and do ingender yll humours, and be oftetymes the cause of putrefyed fevers, yf they be moche and contynually eaten.

ANDREAS VESALIUS, whose *De humani corporis fabrica* (1543) put the science of anatomy on a new basis, quoted Hippocrates' description of the Macrocephali, indorsed the inheritance of acquired characters, and added some remarks of his own on the various head shapes of European nations. From p. 23, ed. of Basel, 1555:

. . . for that reason they [the heads of the Macrocephali] are compressed that way in infancy so that finally they are procreated henceforth by nature in an oblong form. . . . Certain nations have something peculiar in their head shapes. The heads of the Genoese and especially of the Greeks and Turks are almost spherical. The midwives sometimes contribute to this form at the urgent request of the mothers, many of whom think it elegant and well adapted to the turbans which they use in various ways. Indeed the Germans have very flattened occiputs and broad heads because the children always lie on their backs in their cradles. . . . The Belgians have more oval heads because their mothers permit their infants to sleep turned over in their cradles and as much as possible on their sides.

The description of the inheritance of acquired characters which we owe to POLYDORÉ VERGIL does not occur in his *De prodigilis* as we might expect it to, but in his *Historiae Anglicae* (1st ed. 1550). His account showing the inherited effects of Divine punishment is on the exact level as those left by Suetonius and Justinus. From Bk. XIII: 284-285, ed. of 1651:

As a result of words of this sort there were some scoundrels to whom the secret desire of the king seemed to be that Thomas [St. Thomas of Canterbury] should be put out of the way. Therefore, as if considered an enemy of the king, he now began to be so generally disregarded, despised, and hated that when he once came to Stroddum, situated near the Meducia River, which joins the Rochester River, the inhabitants of that place, desirous of inflicting

some disgrace on the good father, did not hesitate to amputate the tail of the horse he was riding, thus making themselves forever guilty for their infamy. For afterwards, by the will of God, it so befell that all of that race of men who had committed the crime was born caudated like brute animals. But those marks of infamy have long since been deleted together with that race of men who sinned.

The passages which tell of the inheritance of acquired characters, in the work of the great mathematician and physician, JEROME CARDAN, deserve particular attention, not only because they show how much the hypothesis could be made to cover, but also because of the author's prominence in the science of his time. Cardan accepted pangenesis and described the origin of semen in some detail in his *Contradicentium medicorum* (here quoted p. 130). His most vivid use of the inheritance of acquired characters, however, is to be found in his *De rerum varietate* (1550). Here he described how some American Indians flattened their heads in a manner reminiscent of the famous passage in the *Airs, waters, places* of Hippocrates. From Bk. VIII, Ch. 43:

This is a worthwhile incident to be marveled at; it is found among the American Indians of old in the Province Portus who although the men were lacking in necks (cervice) had square heads. But this was done through artificial means and not by nature. Nay in truth, this artificially created form grew into a natural one. For the off-spring that had been born from those whose heads had been pressed between plates from the beginning and in turn had had their own heads shaped immediately, had offspring which had contracted a similar form. In truth, whatever is done in variance with the laws of nature brings harm. They, however, think that they will grow healthier and stronger. Yet, the midwife ought to turn toward the natural state and not away from it.

In the following excerpt (Bk. VII, Ch. 37) Cardan explains how dolphins grew to like being called "Simon." His incidental account of his little bitch learning so easily to fetch and carry shows how ancient is the belief that the effects of education are heritable. Even as late as 1938, Professor William MacDougal at Duke University was attempting to measure the inherited effect of teaching rats to solve mazes.

The nature of the process is unclear but it is certain that fish perceive sounds, because they emerge if they are called when they are under the water. Dolphins rejoice in a certain customary name of "Simones," inasmuch as certain vestiges of the usage, as in a wax figure, cling to the animals. So pigeons in certain desert islands of the New World used to be caught by hand, but now they are not. After a descent of many generations they have learnt to fly away from men. My little bitch that was begotten from parents accustomed to fetch things learnt to fetch stones and iron objects in eight days. You may marvel, since you can hardly train another dog in a period of two months, and with great difficulty. Indeed without any training she took to fetching right away of her own accord but she did not carry things off [to indicated places]. Accordingly, dolphins that in former times used to be called by this name (Simon) left a trace of it in their descendants, so that even to this day they rejoice in the name.

In *De venenorum differentiis* Cardan gave his views on hereditary disease. From Bk. I, Ch. 12:

Of contagious diseases there are the hereditary and the non-hereditary, and of the hereditary the contagious and the non-contagious. Shortlived contagious diseases, as pestilential ones, cannot be hereditary. . . . Longlived, established diseases do injure the semen and so are hereditary. As some of these are weakened, they generate a disposition similar to themselves, just as lice and nits do. If they are powerful, they generate a disease which is absolutely similar to themselves. All the rotten hereditary diseases are contagious.

One sixteenth-century application of the hypothesis that acquired characters are heritable has entered into our modern literature. It is to be found in the intellectual squirmings of the hard pressed JACQUES DUBOIS (JACOBUS SYLVIVS, 1478-1555), the teacher and later the enemy of Vesalius. DuBois was so convinced that Galen's anatomical studies of the human body were without error, that he ascribed any discrepancy between the discoveries of his contemporaries and Galen's descriptions to actual changes which had occurred in the human frame. WILLIAM A. LOCY, in his *Growth of biology* (p. 174), cites a somewhat humorous instance.

. . . he [Sylvius] asserted that the straight thigh bones, which, as everyone saw, were not curved in accordance with the teaching of Galen, were the result of the narrow trousers of his contemporaries, and that they must have been curved in their natural condition, when uninterfered with by art.

JOHANN FRIEDRICH BLUMENBACH refers to another attempt by Sylvius to get out of the difficulty in which his defense of Galen had placed him. Sylvius had to explain the absence of the intermaxillary bone in the human skull, for Galen had claimed that it existed. Blumenbach referred to Sylvius in *De generis humani varietate nativa*. From the English translation by Thomas Bendyshe, *The anthropological treatises of J. F. Blumenbach*, 177, London, 1865:

He (Sylvius) so twists about in endeavouring to save his divine Galen, that at last he drops down to this excuse that although men of the present day have no intermaxillary bone, yet at the time of Galen they might have had one; and so this is no reason for attacking the prince of anatomists—"but there are some natural obstructions, which have taken possession of our bodies from intemperance in diet and venery, and from immoderate vice."

OSBORN (*From the Greeks to Darwin*) also notes this extraordinary statement of Sylvius' although he ascribes it to the wrong Sylvius. To quote Osborn (p. 26):

Sylvius (1614-1672) defended Galen warmly, and argued that the fact that man had no intermaxillary bone at present was no proof that he did not have it in Galen's time. "It is luxury," he said, "it is sensuality which has gradually deprived man of this bone." This passage proves that the idea of degeneration of structure through disuse, as well as the idea of the inheritance of the effects of habit, or the transmission of acquired characters, is a very ancient one.

While neither Blumenbach nor Osborn state in which of Sylvius' works this excerpt occurs, they are undoubtedly referring to a passage in *Vesani cuiusdam calumniarum in Hippocratis & Galeni rem anatomicam*, Paris, 1551. From R. HENERUS, *Adversus Jacobi Sylvii*, 82, Venice, 1555:

So that he did not substitute it [the bone] from an ape or a dog like a chicaner, but he sought within the human genus in which it will either appear less prominently or not at all; lest he reproaches Galen, for impediments of a certain nature are caused in our bodies through an intemperate and immoderate use of food and indulgence in venery, and thus defects are produced: about the great change and degeneration in our bodies from that which they formerly were.

JAKOB RUEFF (RUFFUS) described pangeneses at some length in *De conceptu & generatione hominis* (Ch. 1), Zurich, 1554, and appended a short passage citing the inheritance of disease and of peculiar marks on the parents as evidence that the semen came from all parts of the body. The whole description is reprinted on page 131. The last two sentences read:

In addition to these arguments comes the fact that we often observe in children those diseases or defective marks of the body which are present in their parents—things which we entirely believe to have passed into them [the children] through a defect of the seed. And so, having certainly established these facts regarding the origin and material constitution of the genital semen, these things suffice as a preface.

The Dutch physician, LEVINUS LEMNIUS, also used the hypothesis of pangeneses (p. 132) to explain the inheritance of disease. His notion is obviously derived from Hippocrates. From *Occulta naturae miracula*, Bk. I, Ch. 4, Antwerp, 1559:

Seeing that the seed flows from the principal parts, and contains in it the force and nature of all the members, it comes to pass that what disease is in any part, descends by right of succession to the children.

The distinguished JULIUS CAESAR SCALIGER, one of the greatest of sixteenth-century scholars, discussed pangeneses in several of his medical works and described the inheritance of induced modifications in plants. In his comments on *De causa plantarum* of Theophrastus he accounts for beardlessness in wheat as the inheritance of a mutilation. From Bk. V: 287; ed. of 1566:

Section B. Or if you like in all things, the marvel of metamorphosis, observe much about the accidentals. He gives an example from the grains. If you remove from these the tender beards of grain, they will not produce others. Therefore, if you were to do the same thing more often: you will cause them finally to be reproduced without the beards of grain. Nor is the admirable Hippocrates ignorant of this docility of nature. He wrote in his book *De aere et aquis*: "Nature accepted these laws through usage and is finally metamorphosed into these things." Thus the Genoese, since long ago they borrowed a custom from their Moorish ancestors of compressing the heads of their children right after birth and now it follows from

this practice that they are now born *Theisiticus* in respect to their heads and minds. . . . We concede the universal force of the former principle and that from the defective animals are begotten animals that are not defective. But how is it that the wheat which has been gathered and reaped, provided it is done with skill, does not renew its original nature?

AMBROISE PARÉ (AMBROSIUS PARAEUS) explained the inheritance of disease and of acquired characters by pangeneses. The following passages from the preface to his *De hominis generatione*, Paris, 1573, are quoted from the English edition of his *Works*, London, 1634 (tr. by T. Johnson). From p. 885–886:

Good and laudable seed (semen) ought to be white, shining, clammy, knotty, smelling like unto the elder of palme, delectable to bees and sinking downe to the bottome of water being put into it, for that which swimmeth on the water is esteemed unfruitful;<sup>4</sup> for a great portion commeth from the brain, yet some thereof falles from the whole body, and from all the parts both firm and soft thereof. For unlesse it comes from the whole body, every part thereof, all and every part of the issue cannot be formed thereby; because like things are engendered of their like: and therefore it commeth that the childe resembleth the parents, not only in stature and favour, but also in conformation and proportion of his lims and members, and complexion and temperature of his inward parts, so that diseases are oft times hereditary, the weakness of this or that entrall being translated from the parent to the child. There are some which suppose this falling of the seed from the whole body not to be understood according to the weight and matter, as if it were a certaine portion of the blood separated from the rest; but according to the power and forme, that is to say the animall, naturall, and vitall spirits, being the framers of formation and life, and also the formative faculty to fall down from all parts into the seed that is wrought or perfected by the testicles, for proofs and conformation whereof, they alledge that many perfect, sound, absolute and well proportioned children, are born of lame and decrepit parents.

From p. 882:

. . . So that often times the diseases of the parents are transferred or participated unto the children, as it were by a certaine hereditary title: for those that are crooke-backt get crooke-backt children, those that are lame, lame; those that are leprous, leprous; those that have the stone, children having the stone; those that have the ptisicke, children having the ptisicke; and those that have the gout, children having the gout: for the seed follows the power, nature, temperature, complexion of him that engendereth it. Therefore of those that are in health and sound, healthy and sound; and of those that are weake and diseased, weake and diseased children are begotten, unless happily the seed of one of the parents that is sound doth correct or amend the diseased impression of the other that is diseased, or else the temperate and sound wombe as it were by the gentle and pleasant breath thereof.

<sup>4</sup> Many philosophers believe the exact opposite of this. Hippocrates thought that semen was fertile only when it was foamy. Aristotle held that semen was discharged by means of a blast of air, and that the air gave it fertility. Lemnius stated that coition was a churning of air into the semen. Air itself was supposedly sufficient to fertilize the females of a number of species. (C. Z.)

MARCELLUS DONATUS used pangensis to account for the inheritance of disease and even of mutilations. The following quotation is from *De medica historia mirabili*, Bk. VI, Ch. 18, Mantua, 1584:

. . . Thus, from a healthy part healthy seed, from a diseased part diseased seed, whence from bluish grayness [eyes?] we have bluish grayness, from baldhead, baldheads and from the distorted, distorted creations created. Hippocrates and Aristotle enumerate, that even when scar-faced parents have children, these have the same thing at the same part of their bodies. A Chalcedian [woman] since her husband had an afflicted arm bore a son with a similar affliction. However, the known facts have been confused and explained less. Thus, from the imperfections of the semen of parents afflicted with gout children are produced that also have gout, hence from lepers children with leprosy are born and from consumptive parents we have consumptive children. All the doctors unanimously confirm the opinion, and experiments prove it. Many times and not infrequently it is observed that children procreated from the same seeds suffer the same [maladies].

. . . Our universal citizen learned that in the past years a dealer in spices marked with three warts had been father to children whose feet were twisted toward the inner parts of the legs, in such a manner that the toes were placed alternately. It was shown that all the children resulting from the union of father and mother would be afflicted with the same ailment. Thus Nicolas learned why all the children born to a certain noble died of epilepsy, and a certain learned man wrote that all the children of one Laurentius Godius incurred similar deaths from the same disease; many vesicles had been broken in the lungs and even in the adjacent vesicles.

BRUNO SEIDEL discussed hereditary disease in *De morborum incurabiliu causis*, Frankfurt, 1593. In this he described the transmission of an induced deformity. From p. 10:

The shape of the head is certainly of such importance that the activity of the brain and senses within suffer much injury if it is not of the natural and ordinary kind. Hippocrates writes of having compressed certain newly born infants called macrocephali, binding their heads with bands to make them longer and thinner. That practice was so effective that the resulting shape of the head endured even in the adults. In the course of time nature also produced such men, so that it was unnecessary to compress the heads by the earlier method.

From this it appears that the greatest power has been placed in nature's beginnings, and if they depart very much from the right manner and means, no one can easily correct them, although a slight deviation in infants can perhaps be corrected. Sometimes there it may be doubted whether the infants were formed in this fashion or were led to such a misfortune through bad management on the part of the midwife in a difficult delivery. Thus children born with remarkably deformed hands or feet never get over their difficulty in grasping or walking.

An interesting sixteenth-century record is taken from *The haven of health*, London, 1596, written by THOMAS COGAN. This shows that, at the end of this century, the English found fruits and vegetables as dangerous as they had at the beginning. The following passage is obviously derived from Sir Thomas Elyot. From Ch. 99:

For such is the providence of God toward mankind, that he hath not onely provided corne and herbes for our sustenance, but also fruits, flesh and fish. Howbeit herbes and fruites were the first food that ever was appointed to man, as appeareth by the commandment of God given to Adam. And from the time of Adam until Noak's flood the use of flesh and wine was altogether unknown: for before the flood, they did neither eate flesh nor drinke wine. But now by the chaunge of dyet of our progenitors, there is caused in our bodies such alteration from the nature which was in man at the beginning, that now all herbes and fruits generally are noyfull to man and doe engender ill humours, and be ofte times the cause of putrified fevers, if they be much continually eaten.

MARTINUS DEL RIO recorded the inherited effects of the direct action of the Deity in *Disquisitiones magicæ*, Louvain, 1599, by quoting the passage in Polydore Vergil already noted (p. 97) and another passage in *De origine . . . Frisiae*, Bk. II, Ch. 21, Colone, 1588, by CORNELIUS KEMPIUS.

It is well established that monsters are sometimes produced from divine vengeance. It is illustrated in the punishment of the Dockumensian Frisians because of the slaughter of their bishop St. Boniface with his associates.

"For God avenged the ignoble death of these saints (says Kempens) in the children's children so that to this day in the families descended from those who perpetrated such a nefarious crime the members are generally found to have thick whitish hairs at the occiput, like the tail of a certain animal, *ut juxta dixeris*.

"The descendants still perceive what their ancestors committed."

### 3. SEVENTEENTH CENTURY RECORDS

Descriptions of the inheritance of acquired characters are to be found throughout the seventeenth century. Many of them are very precise but some are vague, even ambiguous. We must remember that, at this time, no real distinction was made between congenital blemishes and those due to accidents. The resemblance of children to their parents was recognized and commented on and family peculiarities came in for their just amount of attention. The Hapsburg lip, the Bavarian chin, and goggle eyes were cited by Burton as instances of hereditary defects, as were scars and other signs of wear and tear. Many diseases, regardless of origin or cause, were thought to pass from father to son, and the age at which parents propagated supposedly influenced the temperament of the children. Also children were supposedly subject to prenatal influence and, of course, everyone assumed that the imagination of the mother at the moment of conception determined to a large extent both the physical and spiritual qualities of her offspring. Under these circumstances we must expect to find a great many passages where the inheritance of acquired characters is tacitly assumed but not stated clearly.

JOHANNES SCHENCK of Grafenberg was particularly interested in human monsters and in the anatomical differences between human races. In *Observationum*

*medicarum rariorum*, Frankfurt, 1609, he recognized racial differences in head shape. His explanation of the differences is given in the title of the section in which the matter is treated, "Capita humana pre regionem, populorum, nationum q̄ diversitate cum ab arte tum à natura plurimum variare." Here in Book I, page 8, he quotes the appropriate passages from Hippocrates, Cardan, Vesalius and Scaliger describing the artificial shaping of the heads of infants and the induced inheritance of the novel shapes. These passages have already been quoted.

CASPAR BAUHIN illustrates the general confusion of the time in his *De hermaphroditorum monstrosorumque* . . . , Oppenheim, 1614, where, incidentally, a peculiarity of the father is used to settle a question of disputed paternity. In his essay on hybrids (p. 105-115) he includes the following passage on heredity:

The fourth cause depends on the diseases of each parent—whether the diseases are hereditary or accidental. For from these, monsters and misshapen infants are born. Thus we see the lame produced from the lame, hunchbacks from hunchbacks. Thus the snub-nosed often generate snub-nosed children; stammerers, stammerers; dwarfs, dwarfs; cripples, cripples—for the reason expressed by Hippocrates in the following words in his book "De Genitura":

"When any disease has occurred to them or to their fluid from which the semen comes forth, they do not manifest perfect reproduction but one rather weak around the defective part. There it seems to me not at all strange if they should also be crippled like the parent." To this can be added what we cited above from Hippocrates about the Macrocephali, which matter we have treated quite amply in our book "*De Partibus Similaribus*" (part 1, cap. 8). It would not be out of place to set down here the story that Aristotle used ("*Gen. Anim.*," lib.; cap. 17). He mentions that the father of a certain boy had a tattooed arm and the son had similar markings, although they were confused. Among us, a cobbler by the name of George Hertz had one toe rather large, and his daughter the only child, had a similar toe, which fact was brought to light when he harbored suspicions against his wife, as for a good many years she had lived sterile with him.

ANTONIO ZARA in *Anatomia ingeniorum et scientiarum*, Venice, 1615, mentions pangensis and describes the inheritance of acquired characters just as casually as did Bauhin. He also commented on original sin. From section 9, "To examine the qualities of men from their progenitors":

True it is and frequent; that the silent imagination of a woman absorbing an abundance of impressions from the same source and the consideration of sudden ideas will give to her infant various forms and images. Some of these may represent the grandparents, some others the parents, others may even import the likenesses of other relatives; this nature has denied to other living creatures on account of the dullness of their faculties and the lack of ideas of this type, they are allowed to persist always in that species to which they belong.

What then concerns the faculties of children, is that they are almost of an equal condition with those of the parents, and they are allotted the same nature with them, in them the living spirit and power of thought are infused in the

facilities contained in the seed. It behooves each and both of the parents to strive for equanimity of disposition, to pursue a course of living, maintain a sensible mode of right nutrition, lest either to themselves there should ensue some injury or occasion some vice in their children. Since the semen flows out of all the single parts of the body, and is embraced by the conditions of all the body's members, it follows that whatever taint is in them the child receives as a hereditary right.

Not only this but children often imbibe the sins and shames of their parents. So for us in Original Sin, Adam, the parent of all human mortals, and from this betrayal all human nature has become tainted, and this disgrace is diffused in all posterity; thus for the most filthy children of clerics begotten in abominable cohabitation, a disgrace deservedly stricken by the sacred canons, and by the Sacred Council of Trent, they are cut off from every office and emolument that the infamous parent might have held; thus too for the children of those guilty of offended majesty, even for those begotten previous to the crime, the crime strikes them too. . . . It is certain that wherever the human nature and those organs destined for the begetting of children are so constituted as to be in no way deficient for conception or gestation of progeny, it will produce handsome children after its own type.

ROBERT BURTON, author of the famous *Anatomy of melancholy* (1621), had much to relate of hereditary disease in general and of the transmission of melancholia in particular. Incidental to his treatment of this latter topic he described both the inheritance of acquired character and pangensis. The whole passage (Part I, Sect. 2, Sub-sect. 6, "Parents a cause by propagation"), which contains the following excerpts, will repay a careful study, for it is a very complete and very condensed statement of the dominant seventeenth-century view.

That other inbred cause of Melancholy is our temperate, in whole, or part, which we receive from our parents, which *Fernelius* calls unnatural, it being an hereditary disease; for as he justifies, such as the temperature of the father is, such is the son's, and look what disease the father had when he begot him, his son will have after him, and is as well inheritor of his infirmities as of his land. And where the complexion and constitution of the father is corrupt, there (saith Roger Bacon) the complexion and constitution of the son must needs be corrupt, and so the corruption is derived from the father to the son. Now this doth not so much appear in the composition of the body, according to that of *Hippocrates*, in habit, proportion, scars, and other lineaments, but in manners and conditions of the mind, the habits of the fathers go forth with the children.

The following paragraph needs no comment in the present year but it suggests much:

And sure, I think, it hath been ordered by God's especial providence, that in all ages there should be (as usually there is) once in 600 years a transmigration of Nations, to amend and purify their blood, as we alter seed upon our land, and that there should be as it were an inundation of these Northern *Goths* and *Vandals*, and many such like people which came out of that continent of *Scandia*, and *Sarmatia* (as some suppose) and overran, as a deluge, most part *Europe* and *Africa*, to alter for our good our complexions, which were much defaced with hereditary infirmities, which by our lust and intemperance we had contracted. A

sound generation of strong and able men were sent amongst us, as those Northern men usually are, innocuous, free from riot, and free from diseases.

How careful conscientious parents should be is indicated by the following:

Another cause which some give, inordinate diet, as if a man eat garlick, onions, fast overmuch, study too hard, be oversorrowful, dull, heavy, dejected in mind, perplexed in his thoughts, fearful, &c. *their children* (saith *Cardan subtil. lib. 18*) will be much subject to madness & melancholy; for if the spirits of the brain be fusled or misaffected by such means at such a time, their children will be fusled in the brain; they will be dull, heavy, timorous, discontented, all their lives.

Burton was not optimistic:

For now by our too much facility in this kind, in giving way for all to marry that will, too much liberty and indulgence in tolerating all sorts, there is a vast confusion of hereditary diseases, no family secure, no man almost free from some grievous infirmity or other. When no choice is had, but still the eldest must marry, as so many stallions of the race; or if rich, be they fools, or dizzards, lame or maimed, unable, intemperate, dissolute, exhaust through riot, as he said, they must be wise and able by inheritance: it comes to pass that our generation is corrupt, we have many weak persons, both in body and mind, many feral diseases raging amongst us, crazed families, our fathers the cause of ruin; our fathers bad, and we are like to be worse.

Sir KENELM DIGBY discussed pangenesis at great length (p. 136) in the *Immortality of reasonable souls*, London, 1645. In fact, his treatment is the most detailed presentation of the hypothesis since the speculations of the thirteenth-century theologians. To illustrate the need for some such explanation he cited an instance of the inheritance of a mutilation. From Ch. 23:

Which an accident that I remember, seemeth much to confirm. It was of a cat that had its tail cut off when it was very young: which cat happening afterwards to have young ones, half the kitlings proved without tails, and the other half had them in an ordinary manner; as if nature could supply but one partner's side, not on both. And another particular that I saw when I was at Algiers, maketh to this purpose, which was of a woman that having two thumbs upon the left hand; foure daughters that she had did all resemble her in the same accident, and so did a little child, a girl of her eldest daughters; but none of her sonnes. Whiles I was there I had a particular curiosity to see them all; and though it be not easily permitted unto Christians to speak familiarly with Mohametan women; yet the conditions I was in there, and the civility of the Bassha, gave me the opportunity of full view and discourse with them: and the old woman told me, that her mother and grandmother had been in the same manner. But for them it resteth upon her credit; the others I saw myself.

The learned SIR THOMAS BROWNE sought to demolish many of the superstitions of his age in his famous *Pseudodoxia epidemica*, London, 1646. He was, however, more erudite than critical and he accepted many current beliefs in spite of a total lack of evidence.

Chapter 10 of Book VI is entitled "Of the blackness of negroes." In this he rejects the hypothesis that the negroes became black through inherited sunburn and held on the contrary that their color came from the cumulative effects of jaundice.

Thirdly, it is not indisputable whether it [the blackness of negroes] might not proceed from such a cause and the like foundation of tincture, as doth the black jaundice, which meeting with congenerous cause might settle durable iniquations, and advance their generations unto that hue, which were naturally before but a degree or two below it. And this transmission we shall the easier admit in colour, if we remember the like hath been effected in organical parts and figures; the symmetry whereof being casually or purposely perverted their morbosities have vigorously descended to their posterities, and that in durable deformities. This was the beginning of Macrocephali, or people with long heads, whereof Hippocrates hath clearly delivered himself. . . . Thus as Aristotle observeth, the deer of Arginusa had their ears divided; occasioned at first by slitting the ears of deer. Thus have the Chinese little feet, most Negroes great lips and flat noses; and thus many Spaniards, and Mediterranean inhabitants, which are of the race of Barbary Moors (although after frequent commixture), have not worn out the Camoys nose unto this day.

PIERRE GASSENDI used the supposed existence of the inheritance of mutilations as evidence of pangenesis. The passage is to be found in his *Animadversiones in decimum librum Diogenis Laertii*, etc., Lyons, 1649.

Meanwhile add this argument, which can be proposed, concerning the mutilated offspring which the mutilated produce. No more appropriate cause for this fact can be given than that nothing can flow from parts that do not exist, if, indeed, with Aristotle there could be made a confirmation of the transmutation of matter, not the accession of parts similar to similar parts, which he assails in "Anaxagoras" and other works; there is no reason why perfect parts do not arise from imperfect. Indeed, occasionally unimpaired offspring are born of mutilated parents; but this can happen either because of the soundness of the one parent or because of the strength of the spirits, or because of some other reason. At all events, while mutilation is of consideration, it can be seen that its cause is plain enough. Do you say that perhaps it depends on the imagination of the mother? Yet, I should not mention a woman who gave birth to a son who had no fingers on the same hand on which her husband had lost his by a blow from a weapon; I also propose the fact of a dog who had healthy puppies, but, after her legs had been broken one after another by being struck with rocks, she produced lame puppies. Indeed, do you think that little dog thought of her lameness between her conceptions? Another remarkable thing which would be to your advantage to consider is, whether that Chalcedonian boy, of whom Aristotle makes mention, was born with a punctured arm because his father had punctured his; you must make certain whether these parts we have selected to consider were from any parts at all.

NATHANIEL HIGHMORE discussed pangenesis in almost as much detail as did Digby (p. 137). He also cited an instance of the apparent inheritance of a mutilation but he thought that the matter was rather complicated. Certainly mutilations were not always in-

herited. From *History of generation*, 31, London, 1651:

This seems to be very much befriended by our Authors relation of the cats kited without tails; and of the Woman's daughters with six fingers upon a hand. Myself also have seen a kinde of Poultry without rumps: which breeding with their own kind still brought forth Chichen wanting that part: If with others, sometimes they had rumps, sometimes but part of a rump. And not long since I saw a Mungril Bitch, that had her tail cut close to her body almost, whose Whelps were half without tails, and half with tails: the next year following, she brought them forth all with long tails, as she had before the cutting off. Which though it seems to favor (as I said) this opinion, it doth in no way confirm it; as may appear by the frequent perfect generations of mutilated creatures; which beget children or issue with two legs or arms though they had but one; Spaigniels, whose tails are always cut, bring forth Whelps whose tails need as much cutting, as their Dams or Sires did. We must therefore look out some other way, how this may be done without the parts themselves.

PIERRE BOREL recounted the remarkable instance of an accidentally acquired defect reappearing in the succeeding generation. The explanation offered is pangenic. From *Historiarum et observationum medico-physicarum*, Paris, 1656, from Cent. I, obs. 7:

The following case which occurred in a certain suburb near Tholosa well deserves to be considered remarkable. When he was only fifteen years old an overseer dislocated his knee from a blow so that for the remainder of his life he was lame. Some time after receiving the blow he married and had by his wife two normal children whose bodies were well-formed until the fifteenth year. At the expiration of the fifteenth year the bones of their knees became spontaneously dislocated, the father's defect having been produced in them by heredity and breaking out in them in the same year in which he had incurred the dislocation.

This occurrence, indeed rare, remarkable, and at the same time very true, might furnish material for a whole volume, but it will suffice for me if I say that the semen is a very pure substance of the whole blood and flows down from all parts of our body. Hence it transfers the pattern and form, as well as the defects and diseases, of the parents to the children. Yet these do not usually appear immediately upon birth because the defects are somehow corrected and held in check by the mother's semen. Finally after a struggle of many years the male semen prevails over the female semen, or vice-versa, and so what was predestined comes to pass, as, Paracelsus and the doctissimus Severinus Danus say. Therefore it is not strange that a natural luxation follows, taking its deformed abode.

Le Faucheur, a priest of the church of Carenton, knew a man, physically sound, who married three times, women that were likewise normal, and yet all his children were lame. That state of affairs, then, resulted from the hereditary defect of the grandparents arising again in them. Hence it is the case that children generally resemble in their features not the parents but the grandparents or ancestors farther back.

The ancient problem of human racial differences, particularly differences in skin color, seemed to demand that acquired characters be inherited when the assumption was made that all mankind were descended from Adam. ISAAC VOSS used the usual explanation in his

Commentary upon *De situ orbis* of Pomponius Mela (1st ed. 1658). His comment is on Bk. III, Ch. 9, *De Aethiopia* (p. 864, ed. of 1748):

This is the true reason, because of this reason the Mauri and various tribes of Indians and negroes have flat nostrils, because without doubt they were just broken at birth. Their theory is ridiculous who will write that it is caused from a striking on the back and head of pregnant mothers. But they did not reason well who deny that the features have been broken in this race by Mauri women, for children there are also born with flat noses and they are not formed that way artificially. This may be passed over for the truth remains in the other theory.

The artificial habit without a doubt developed into natural one which idea was found even among the Macrocephali; the author is Hippocrates. The greater the length of their heads the more noble were they considered. The infants, therefore, immediately after birth had their heads at first squeezed together with the hand, then with bands so that a round head formed by nature grew into an oblong shape. This when it was performed was thus originally an artificial shaping and gradually the habit went into nature. Even from those with artificially prepared heads had offspring with similar longshaped heads.

I do not believe that any other theory is necessary to explain the blackness of the negro. They were not entirely black which is because of their filthiness, because they have anointed themselves with a black juice (these are negroes of a whitish color). They change this swarthy colour into black. Here an artificial coloring develops into a natural phenomina that was formerly an artificial creation now is a natural color.

GASPAR DOS REYS-FRANCO described hereditary disease in *Elysius jucundarum quaestionum campus*, Brussels, 1661. The inheritance of acquired characters is described, although not very explicitly. From *Quaest.* 54, § 17, p. 402:

Therefore it is held that hereditary diseases originate from this cause. The parent who can reproduce a son resembling himself in respect to the outermost features also infuses into him with the semen any internal weakness of the parts. Accordingly, not all diseases are carried over with the semen but only those becoming firmly rooted which have greatly worn down the parts by their long duration and implanted deep in them an irregular, morbose quality. Thus we see that long-established diseases are communicated through the semen, but those of brief duration and fortuitous in their invasion are not so communicated.

ANTOINE LE GRAND, the Augustinian missionary to England, published *Historia naturae* in 1673. In this and in a previous work (p. 137) he described how the semen collected from all parts of the body and thus how mutilations could be inherited. From Pt. VIII, Art. 2, Ch. 2:

And it is this Semen which the Animal uses for the procreation of those like unto himself. But if the animal from which the Materia Spermatica is produced, happens to lack any member (or to be overburdened by the superfluity of any part) then the virtue of that member will not be in the blood, and therefore the offspring will be born maimed and lacking some part. If, in truth, parts [of the body] of the animal are multiplied as *Digbaeus* mentions in his *African Women*, or, if a superfluity accretes, it will



effect a deformity in the offspring also; unless this superfluity is balance in the semen of the other parent, or the over-abundance of the blood (i. e. the over-abundance in the blood of the virtue of the excrescent part) is corrected.

JOHANN NICOLAUS PECHLIN expressed himself eloquently and at length upon the practice of various savage tribes of mutilating themselves and of distorting their normal bodily growths so that they would conform to some primitive standard of beauty. He even payed his respects to his so-called civilized European contemporaries, who also took pains to be beautiful. In doing so he had occasion to refer to Hippocrates' account of the Macrocephali. From *De habitu et colore Aethiopum*, 32, Kiel, 1677:

In Hippocrates the propagation of the Macrocephali is ascribed partly to artificial means, partly to nature, i.e., with their own hands, they first used to shape the head, still soft and tender, into the form in which it ordinarily results in the infants, and then to tie it with bands in such a way that through the forcing up of nourishment lengthwise rather than sidewise on account of the stricture, the natural proportion was vitiated, the structure of the frontal bones sloping perceptibly. This practice, then, repeated quite frequently, passed over into nature either through the force of the imagination or through the ideal impression of the semina, and the Macrocephali were produced without effort.

SIR MATTHEW HALE is an almost unknown pre-Darwinian evolutionist. The writer has called attention to the fact that he recognized the struggle for existence and that he anticipated Malthus in listing the checks to an excessive increase of population. In spite of the fact that he believed in degeneration (mutation), the inheritance of acquired characters and the formation of new varieties and species through hybridization, he accepted literally the biblical account of creation and Noah's flood. He was thus faced with the problem of explaining how the many species of animals found only in the New World could get to their distant home from Mt. Ararat without leaving individuals of their kind in Asia. In his explanation he assumed that every species of animal (also human beings) were modified through climatic factors operating through many generations. From *The primitive origination of mankind*, 200, London, 1677:

And there is no less difference in the Humors and Dispositions of People inhabiting several Climates, than there is in their Statures and Complexions. And it is an evidence that this ariseth from the Climate, because long continuance in these various Climates assimilate those that are of a Foreign extraction to the Complexions and Constitutions of the Natives after the succession of a few Generations.

And upon this account there may be great variety in the Colour, Figure, and Make of divers Birds and Animals in *America* from those in the Eastern World, and yet both have the same original extraction; for there is no less variety in the Brutes and Birds of *Africa* from those of *Europe* or *Asia*, and yet nothing impedes their mutual commigrations, being the same Continent, though differing Climates.

THOMAS BURNET's literal acceptance of the scriptural account of creation and the flood led him, as it did Roger Bacon, to the hypothesis of inherited modifications. Holy Writ had recorded the long lives of Methuselah and the other Antediluvians yet we, their descendants, were fortunate if we reached three score years and ten. This was owing, he held, to the cumulative effects of mankind living on a planet which had become far less salubrious than the earlier pre-flood world. To show how reasonable his hypothesis was he referred to two comparable instances, which were accepted by his contemporaries. In *The sacred theory of the earth* (1681-1689), he stated (Bk. II, Ch. 2, p. 263, ed. of 1719):

As when some excellent Fruit is transplanted into a worse Climate and Soil, it degenerates continually till it comes to such a degree of Meanness as suits that Air and Soil, and then it stands. . . . We see the *Blacks* do not quit their Complexion immediately, by removing into another Climate, but their Posterity changeth by little and little, and after some Generations they become altogether like the People of the Country where they are.

The great botanist and pre-Linnean systematist, JOHN RAY, used the hypothesis of pangenesis to explain the inheritance of acquired characters in *The Wisdom of God manifested in the works of creation*, London, 1691:

Yet it must be confessed that the Seed of Animals is admirably qualified to be fashion'd and form'd by the *Plastick Nature* into an organical Body, containing the Principles or component particles of all the several homogenous Parts thereof; for indeed every part of the Body seems to Club and contribute to the Seed, else why should parents that are born blind or deaf or that want a finger or any other Part, or have one superfluous, sometimes generate Children that have the same Defects or Imperfections? . . .

The seventeenth-century records can be brought to a close on a note of skepticism. The skeptic was an anonymous Master of Arts from Oxford and his initials were L. P. In 1695 he wrote *Two essays sent in a Letter from Oxford to a Nobleman in London. The first concerning some Errors about the Creation, General Flood, and the Peopling of the World, etc.* The essays were published in *Somers Tracts*. The author was convinced that the inhabitants of the several continents had been created separately and that consequently all mankind was not descended from Noah. Thus he did not have to explain the physical differences of human races by a "descent through modifications" from a single source. He denied that "accidental" characteristics were inherited. From *Somers Tracts* XII: 20-33, 2nd ed., London, 1814:

'Tis plain, their [negroes] colour and wool are innate, or seminal from the first beginning, and seem to be a specifick character, which neither the sun, nor any curse from Cham could impress upon them. . . . This colour (which appears to be as ingenite, and as original as that in whites) could not proceed from any accident; because, when animals are

accidentally black, they do not procreate constantly black ones, (as the negroes do) as in dogs, cows, sheep and in some birds: accidental colours vary in the same numerical subject by changes of season, of diet, of culture, &, but a negro will always be a negro, carry him to Greenland, give him chalk, feed and manage him never so many ways.

#### 4. EIGHTEENTH CENTURY RECORDS

Records of the inheritance of acquired characters are really numerous in the eighteenth century, probably more numerous than in the two preceding centuries combined. During this period comparative anthropology was coming into being and anthropologists were concerned with the origin of human racial differences. The universality of Noah's flood was still generally accepted which implied, of course, that all races were closely kin. The missionary had to look upon the cannibal as his own 130th cousin. How, then, were the observed special racial characters to be explained? The most obvious explanation was that the slight physical modifications caused by the climate were heritable and cumulative from generation to generation. Black skin was thus the end result of many generations of sunburn.

Another source of the records is in the writings of the eighteenth-century physicians who were interested in hereditary disease. At this time most diseases, supposedly, were conditioned by an hereditary taint. No distinction whatever was made between congenital family peculiarities and those due to accidents, with the natural result that the inheritance of acquired characters was tacitly accepted in numerous medical works. Lamarck, born in 1744, could hardly have escaped a hypothesis which was so universally accepted. In fact more than twenty of his contemporaries described the inheritance of acquired characters before he used the hypothesis to explain evolution.

VINCENTIUS RUMPF was quite precise in describing the cumulative effects of climatic influences in *Dissertatio critica de hominibus orbis nostri incolis, specie et ortu*, . . . Hamburg, 1721, a work often erroneously ascribed to J. A. Fabricus. This was translated into English by T. Bendyshe and published in the *Memoirs of the Anthropological Society of London* 1: 372-418. Rumpf listed the many known effects of environmental changes on both plants and animals and, of course, on human beings. Extremely divergent types in different regions, he argued, could have had a common origin. He rejected the polyphyletic origin of human races and asked, "What, then, is there in all this, even in that diversity of color which is seen in men, or that discrepancy which is found in the form and style of bodies, to argue as a necessary consequence a diversity of origin, besides that from Adam?" He describes the inheritance of acquired characters as follows:

Secondly. It may be the case that, in long successions of generations, nature may degenerate from the very purest white to the deepest black, until at last this becomes so con-

firmed in the body that it remains, and is propagated with the blood itself and is an efficient cause of carrying on the blackness to posterity. Hence, it seems less remarkable that the majority of the Jews who live on the Malabar coast have become as black as the Ethiopians; and only a Jew whose ancestors, perhaps, arrived there later, has retained that whiteness the progenitors of their race had in the outset, or something approaching to whiteness. This we learn from Phil. Baldaeus, and from the author of a letter sent a few years ago from India to Belgium, the gist of which has been repeated at length by Ludolph Kuster.

*Oeuvres diverses de physique et mécanique*, Leiden, 1721, appeared with CLAUDE and PIERRE PERRAULT as authors. Claude Perrault had died in 1686. Just which of the authors is responsible for their conception of the mechanism of heredity, or just when their concept took form, is uncertain. At any rate their notions seem very peculiar in the twentieth century, but were quite orthodox in the eighteenth. From Ch. 9:

If maimed parents are sometimes seen to produce children with the same imperfections, it is not hard to perceive that that can come about from the mother, whose imagination, which has the power of affecting the humors and consequently making them flow toward some parts rather than toward others, has, for example, failed to develop the tiny hand which has remained at the end of the arm, just as flowers and fruits are at the end of branches, which have not yet bloomed because those parts are not yet developed. If, on the contrary, it happens that some supernumerary parts are added, as a sixth finger, a third arm, a second hand, and everything else that goes into the formation of monsters, it is still easier to understand that that composition of parts added could have been made by the meeting of two tiny bodies whose parts became joined and developed, some of them, variously in consequence of the movements of the humors variously agitated by the imagination, . . .

As to the difficulty involved in explaining how that can be effected even without the image, as when a blind father and a blind mother beget a child resembling them, or when a child resembles ancestors never seen by the father or mother, there is always almost the same difficulty in any system. For if the ordinary system supposes that ancestors have given to those engendered from them such dispositions which make the parts produced in them for the preparation of the reproductive material, and which give to the particles of this material particular configurations and a readiness to be affected in a suitable manner to produce one figure rather than another in the parts of the bodies engendered from this material, and that these dispositions are made suitable to produce those effects, then the particles have no need of being determined there by the imagination: . . .

TOBIAS WIRTH published *De morbis haereditariis*, Copenhagen, 1734, as his inaugural dissertation. His discussion of hereditary diseases shows that he accepted tacitly both pangenesis and the inheritance of acquired characters. In § 7 he quotes a passage in Aristotle with obvious approval:

In Book VIII on the history of animals Aristotle writes thus: injured are begotten from injured; for example, lame from the lame, blind from the blind. In the same mentioned place in Chapter XVIII crippled are begotten from crippled, and when the parents have had scars, some of the sons were marked similarly in the same place; and lastly

those having marks, innate and hereditary to them, as warts, moles and scars, or any other thing of the same family. Paraeus in Book XXIII on hereditary defects says, how cripples and hunch-backs, are produced. . . . Stolid and demented parents hardly ever beget ingenious offspring.

In § 11 Wirth describes the inheritance of blemishes and mutilations:

Now in appearance authors proclaim that gout is generally of a seminal origin, since experience proves this fact sufficiently and since the most celebrated men of our time have also affirmed it, hereditary disposition should be counted among the causes of that war. In his book on transplantation of diseases Herman Grube declares that scurvy and roving gout are hereditary. Fred. Hoffmann observed that mange, especially dry, is spread into the begotten: many others besides Hoffmann declare that ulcers with which parents were afflicted have also attacked the offspring. Hildanus has seen intestinal hernia lasting into the third generation. Warts and scars are also observed in descendants, just as Aristotle mentions in Book I, in his history on animals.

One of the best examples of the use of the inheritance of acquired characters to explain human racial differences is to be found in "An essay upon the causes of the different colors of people in different climates" written by the famous JOHN MITCHELL in the very year that Lamarck was born. Mitchell sent the essay from his home in Urbana, Virginia, to his friend Peter Collinson in London who read it to the Royal Society at several meetings between May 3 and June 14, 1744. The essay was then printed in the *Philosophical Transactions of the Royal Society, London*, 43: 103-150. Mitchell was convinced that all human beings belong to a single species, regardless of their present physical diversities, and that they are all descended from Noah. Noah, he thought, was neither white nor black, but tawny, the color of the southern Tartars of Asia or of the American Indians. He noted that the sun could cause white men to become tanned and cause the naturally dark to become black. Thus the color of a man was directly conditioned by his environment, and the environmental influences extending over several generations were sufficient to produce the known human racial differences. From p. 149:

. . . Besides, we want not some convincing Instances, from the Gleanings of the few Historians I was furnished with here, to shew that such Changes have happened in the Memory of Men, and within the Compass of those Records we have of Time; for we could not suppose it to have happened all at once: Thus *Herodotus* tells us That the *Colchi* were formerly black, with frizzled Hair; which (he says) he relates rather as a Thing well known before, than a bare Report; but there is no sign of any Blackness in the Complexions of their Descendants, they being rather, especially about *Circassia*, reckoned some of the fairest People in the World at this Day.—*Captain Smith* tells us, that even in *Virginia*, an *Englishman*, by living only three Years among the *Indians*, became "so like an *Indian*, in Habit and Complexion that he knew him not but by his tongue." And what might his Children have turned to in Succession of many Generations, by these same Ways of Life, which had so altered him in three Years?—The Moors

and *Lybians*, being drove out of *Africa*, upon the *Turkish* conquest, retired to the Land of the Negroes—; but are no more to be found their of their original tawny Colour. The King of *Gualata* is supposed to be lineally descended from these tawny *Moors*, but is even blacker than the original Negroes. The *Habessines*, who come from *Arabia* originally, are no longer of their swarthy Complexion, but have got the black Complexion of the *Ethiopiens*, whose country they possess. The *Mosemleeks* of *Canada*, who wear Cloaths, and are more civilized than the other Savages their Neighbors, who go stark naked, are so much more refined in their Complexions by this Usage, as to be taken for *Spaniards*, and not *Indians*. Nay, the *Spaniards* themselves, who have inhabited *America* under the Torrid zone, for any Time, are become as dark coloured as our native *Indians* of *Virginia*, as I have been an Eye-witness: And were they not to intermarry with the *Europeans*, but had the same rude and barbarous Lives with the *Indians*, it is very probable, that, in a Succession of many Generations, they would become as dark in complexion.

The famous P. L. M. DE MAUPERTUIS was more or less inclined to doubt the inheritance of acquired characters although he admitted the possibility of such inheritance. He did accept pangenesis in both his *Vénus physique* (1745) and his *Système de la nature* (1751). In the former work he stated the problem of the cumulative effect of artificial modification. From Part II, Ch. 5:

Although I suppose that here the basis of all these varieties is found ultimately in their seminal liquids, I do not exclude the influence which climate and nutrition can have. It seems that the heat of the torrid zone is more suited for the formation of the particles which render the skin black, than for those which make it white; and I do not know whether this can be obtained by the influence of the climate or of diet after many centuries.

It would certainly be something which deserves the attention of philosophers, to test whether certain artificial modifications of animals would not pass, after many generations, to the animals descended from them; if the tails or the ears trimmed from generation to generation would not become smaller or even, at last, be destroyed.

This, however, is certain that all the varieties which distinguish new species of animals and plants tend to vanish: they are the errors of nature, which are not preserved except by art or training. These deviations always tend to return to the normal.

BENOIT DE MAILLET differed from Maupertuis in just about every view that he expressed. He believed that there were many different species of men including species of giants, dwarfs, tritons, etc. He derived all land forms from parallel sea types, cows from sea cows, dogs from sea dogs, men from mermaids (or the mermaid's husbands), birds from flying fish, etc. In his fantastic *Telliamed* (1st. ed., 1748) he never let known facts interfere with his speculations. He described how the change from water-living forms to air-breathing creatures could be consummated in a single generation. He has been cited as believing that these acquired modifications were passed on to the following generations which would not revert to the original types. Some of his descriptions would seem to imply this view but in other passages he makes it clear that nature does not

need the slow, cumulative effects of environment spread over several generations. Environment, he thought, was so powerful that it could cause species changes in a single saltation. The descendants of his new forms maintained their characteristic structure only because they remained in the new environment. He actually told of an instance of a Dutch boy returning to live in the sea.

With GEORGE LOUIS LE CLERC DE BUFFON (1707–1788) we definitely leave the lunatic fringe, where de Maillet belongs, and come to the leading naturalist of his time. Buffon's conception of pangenesis (p. 141) differed in certain details from that of Charles Darwin. It was, in fact, a rival hypothesis and was accepted by some leading zoologists until late in the nineteenth century. He also believed that mutilations and acquired characters were inherited. From *Histoire naturelle* IX: 328, ed. of 1812, edited by M. Wood:

The augmentation, or diminution, of its size, is caused by the care taken to unite the great with the small individuals. The shortness of the ears and tail proceeds also from the hand of man. Dogs which have had their tails and ears cut for a few generations transmit those defects wholly, or partly, to their descendants.

From Vol. III, p. 443–446:

Upon the whole, every circumstance concurs in proving that mankind are not composed of species essentially different from each other; that, on the contrary, there was originally but one species, which, after multiplying and spreading over the whole surface of the earth, has undergone various changes by the influence of climate, food, mode of living, epidemic diseases, and mixture of dissimilar individuals; that, at first, these changes were not so conspicuous, and produced only individual varieties; that these varieties became afterwards more specific, because they were rendered more general, more strongly marked, and more permanent, by the continual action of the same causes; that they are transmitted from generation to generation, as deformities or diseases pass from parents to children; and that lastly, as they were originally produced by a train of external and accidental causes, and have only been perpetuated by time, and the constant operation of the causes, it is probable that they will gradually disappear, or at least, that they will differ from what they are at present, if the causes which produced them should cease, or if their operation should be varied by other circumstances and combinations.

The inheritance of acquired characters was even implied in some of the contemporary economic literature. A good example of this is to be found in CLAUDE JAQUES HERBERT'S *Essai sur la police général des grains*, Paris, 1755. Herbert was concerned with the effects of malnutrition on the French peasants, and stated (p. 330),

In whole Cantons, the inhabitants badly sheltered, badly nourished, livid and decrepit before their time, are unable to beget a vigorous posterity.

MICHEL ADANSON was Lamarck's predecessor at the Jardin Royal. In 1763 he published his *Familles des plantes* and here he postulated the inheritance of acquired characters. From the preface, p. CXII:

In plants which reproduce by seed, there occur, without the aid of alien impregnation, changes produced either by the reciprocal fertilization of two individuals, differing in some one character although of the same species, or by the cultivation, soil, climate, dryness, moisture, shade, sunlight, etc. These changes are more or less sudden, more or less durable, either disappear in each generation or *perpetuate themselves for several generations*, according to the nature, disposition and habit, so to speak, of each plant.

Incidentally, Adanson explained the origin of new varieties through chance mutations. From p. CXIII:

It appears therefore to be proved sufficiently by the facts cited above that art, cultivation and especially chance, i.e., certain unknown conditions, bring forth every day not only varieties of rare flowers such as Tulips, Anemones, Ranunculi, etc. . . . but even some new species. . . . From this arises the difficulty of defining what the original forms of the Creation are and what are those which have been changed by the succession of reproduction. . . .

The remarks of the famous Swiss naturalist, CHARLES BONNET, are especially significant in that he denied that mutilations were ever inherited even if they were repeated for several generations. Lucretius had denied the inheritance of acquired characters and Vincent of Beauvais had denied that mutilations were heritable, but those who held this view were only a small minority. There is little doubt but that Bonnet stood almost alone in his time, although, later, some eighteenth-century and early nineteenth-century naturalists stated definitely that acquired characters disappeared with the generation which acquired them. Bonnet, strangely enough, believed in a sort of modified pangenesis (p. 143) wherein animal spirits diffuse into the ovaries instead of pangens. He denied the inheritance of mutilations in his *Considérations sur les corps organisés* (1762). From vol. III, p. 461, ed. of 1779:

One sees that, according to my hypothesis, the tails [of dogs] cut off from the males from generation to generation, would not be shortened or ultimately eliminated, if their primordia had been originally provided. This would happen inevitably, if the tails of the males supplied the molecules whose unison formed those of the primordia. But in amputating the tail of the male, one does not cut off the corresponding part from the generating organ which, I suppose, corresponds to the coccix.

A foot-note to the above follows:

I am not at all surprised that M. de Buffon has believed in this race of dogs deprived of their tails. It is in accord with his ideas of generation. He has imagined that each integral part of the individual generated is composed of interior molds which fashion the organic molecules. The amputation of the tail of a dog would involve the amputation of the mold of the tail. But for two centuries the English have cut the tails of their horses, yet these are still born with their tails. For a still longer period, the Hottentots have cut out one testicle from their babies yet all the Hottentots are born with two testicles. A blind man has offspring with two eyes, a one-armed man has infants with two hands.

He denied the inheritance of mutilations also in a letter to Lazaro Spallanzani dated Jan. 9, 1768. From *Oeuvres d'histoire naturelle* V: 52, Neuchatel, 1781:

You have very well my principles on Generation. In Vol. XIV of his Natural History, M. de Buffon assures, that he saw Dogs whose ears and tail had been cut from generation to generation, and which transmitted these defects in whole or part to their descendants. He enters into no detail thereon, and does not say how he is sure of this. It is worth much trouble to say it. You see this is directly opposed to what I advance, Article 337 of *Organized Bodies*. But English Horses whose tails have been cut for two centuries, do they not refute M. de Buffon and render suspicious the fact that he states as certain? Add to this the testicles of the Hottentots and the Abyssinian nymphs.

JOHN GREGORY, a Scottish physician, published *A comparative view of the state and faculties of man with those of the animal world* in 1766. Here he discussed the interaction of heredity and environment in a number of passages. He was a bit of a eugenicist but was completely confused as to how the race was to be improved. In the following passage (p. 17, 8th ed., Dublin, 1788) he tacitly blends artificial selection with the inherited effects of environmentally caused deviations.

We should likewise avail ourselves of the observations made on tame animals in those particulars where Art has in some measure improved upon Nature. Thus by a proper attention can we preserve and improve the breed of Horses, Dogs, Cattle, and indeed of all other Animals. Yet it is amazing that this Observation was never transferred to the Human Species, where it would be equally applicable. It is certain that notwithstanding our promiscuous Marriages, many families are distinguished by peculiar circumstances in their character. This Family Character, like a Family Face, will often be lost in one generation and appear again in the succeeding. Without doubt, Education, Habit, and Emulation may contribute greatly in many cases to preserve it, but it will generally be found that, independent of these, Nature has stamped an original impression on certain Minds, which Education may greatly alter or efface, but seldom so entirely as to prevent its traces from being seen by an accurate observer. How a certain character or constitution of mind can be transmitted from a Parent to a Child, is a question of more difficulty than importance. It is indeed equally difficult to account for the external resemblance of features, or for bodily diseases being transmitted from a Parent to a Child. But we never dream of a difficulty in explaining any appearance of Nature, which is exhibited to us every day.—A proper attention to this subject would enable us to improve not only the constitutions, but the characters of our posterity. Yet we every day see very sensible people, who are anxiously attentive to preserve or improve the breed of their Horses, tainting the blood of their Children, and entailing on them not only the most loathsome diseases of the Body, but madness, folly and the most unworthy dispositions, and this too when they cannot plead being stimulated by necessity, or impelled by passion.

WILHELM JOSEPHI tacitly assumed the inheritance of acquired characters in *Grundriss der Naturgeschichte des Menschen*, Hamburg, 1770. From p. 95, ed. of 1790:

What causes the slime (which determines color of skin) to be a certain color?

The most probable cause is the climate, for it has been found that the darker the color of the skin is, the hotter is the climate and vice versa. . . . Another influence is the mode of living, i.e., type of food and uncleanness as is seen among the Eskimos whose white color is darker and is gray.

All the mentioned colors are now continued through reproduction, although the children of all races are born alike in color—a reddish and rather similar color. Yet in a few days the distinct color of its parents appears.

PIERRE CAMPER is a perfect example of the eighteenth-century anthropologist who recognized human racial divergencies yet derived all men from Adam. It is easy to see how useful the hypothesis that acquired characters were heritable has been to anthropology. Camper used the hypothesis in a public address given in Groningen in 1764, entitled *De l'origine et de la couleur des nègres*.

Reprinted in Camper's *Oeuvres* II: 474, 1803:

Whether Adam was created brown, tawny, black, or white it is always necessary to admit that his descendants, from the moment that they were dispersed on the surface of the earth, altered their traits and their color according to the climate which they were going to inhabit, the food with which they nourished themselves and the illnesses with which they were attacked. Accidental causes must have also contributed by heritage, as one still sees daily. The mixture of two so strongly ill-sorted races between themselves must necessarily have produced a new one, which took several things from one and from the other, and whose character could not have altered except at the end of a certain number of centuries.

The inheritance of acquired characters is also described in another passage. From vol. II, p. 368:

If such changes can operate in a few years; if our co-patriots which have lived in burning climates, can never after their return to our country, regain the whiteness of their tint, then how much more should not this color be inalterable, from generation to generation, when the residence in the same climate has lasted over several consecutive centuries. But since the time of this meeting is limited, I should be concise; without which I should perhaps be able to prove in a convincing manner that America was peopled by colonies drawn from the northern parts of Europe and Asia, which multiplied there, and which, as Buffon remarks rightly, went south to evade the cold, and that their light brown color became darker to the extent with which they inhabited warmer countries. It is probably several centuries since these emigrations were made. One may draw the proof for that from the small number of men who people America, as well as from the savage manners which are theirs, except certain tribes, who perhaps owe their origin to some more civilized people of Europe, who were thrown there by shipwreck, and who lost the manners of their ancestors in time.

Perhaps no evidence as to how widespread the belief in the inheritance of acquired characters was during the latter portion of this century is more striking than the fact that such inheritance is taken for granted in popular literature. OLIVER GOLDSMITH, the poet and novelist, wrote a *History of the earth and animated nature*,

London, 1774. Perhaps, the sole value of this history lies in the fact that it shows what the generally accepted beliefs were at the time it was written. Two passages in this work describe the inheritance of acquired characters. In explaining the origin of the skin color of the American Indians Goldsmith wrote (vol. II, p. 236):

But it must be considered that they live continually exposed to the sun; that they use many methods to darken their skins by art, painting them with red ocher, and anointing them with the fat of bears. Had they taken, for a succession of several generations, the same precautions to brighten their colour that an European does, it is very probable that they would in time come to have similar complexions; and, perhaps, dispute the prize of beauty.

The origin of racial peculiarities is explained as follows (vol. II, p. 238):

The form of the face seems rather to be the result of custom. Nations who have long considered some artificial deformity as beautiful, who have industriously lessened the feet, or flattened the nose, by degrees, begin to receive the impression they are taught to assume; and Nature, in a course of ages, shapes itself to the constraint, and assumes hereditary deformity. We find nothing more common in births than for children to inherit sometimes even the accidental deformities of their parents. We have many instances of squinting in the father, which he received from fright, or habit, communicated to the offspring; and I myself have seen a child distinctly marked with a scar, similar to one the father had received in battle. In this manner accidental deformities may become natural ones; and by assiduity may be continued, and even increased, through successive generations. From this, therefore, may have arisen the small eyes and long ears of the Tartars, and Chinese nations. From hence originally may have come the flat noses of the blacks, and the flat heads of the American Indians.

The same year that Goldsmith's *History* appeared, JAMES BURNET (LORD MONBODDO) published his remarkable work, *Of the origin and progress of language*. Here the inheritance of acquired characters is tacitly assumed. From vol. I, p. 300:

... An it is for this reason, that the offspring of a savage animal will never be so tame, whatever pains may be taken upon him, as the offspring of a tame animal. And, I am persuaded, it is with wild men, as with wild fruits, which we know will not lose their savage nature at the first remove, but can only be tamed by continued culture for a succession of generations.

On the other hand, another nobleman, LORD KAMES (HENRY HOME), joined the small minority who believed that acquired characters were *not* heritable. His disbelief is expressed in his *Sketches in the history of man*, Edinburgh, 1774. From p. 13:

Those who ascribe all to the sun, ought to consider how little probable it is, that the colour it impresses on the parents should be communicated to their infant children, who never saw the sun: I should be as soon induced to believe with a German naturalist, whose name has escaped me, that the negro colour is owing to an ancient custom in Africa of dyeing the skin black. Let a European for years

expose himself to the sun in a hot climate, till he is quite brown, his children will nevertheless have the same complexion with those in Europe. The Hottentots are continually at work, and have been for ages, to darken their complexion; but that operation has no effect on their children. From the action of the sun is it possible to explain, why a negro, like a European, is born with a ruddy skin which turns jet black the eighth or ninth day?

JOHN HUNTER (not the famous surgeon of that name) delivered an inaugural dissertation in June 1775 in Edinburgh, entitled *Disputatio inauguralis quaedam de hominum varietatibus, et harum causis, exponens*. This was translated into English by Thomas Bendyshe and published by the Anthropological Society of London in 1865. Hunter committed himself wholeheartedly to the generally accepted hypothesis that the different races of human beings arose through the cumulative effects of environmental modifications. The following quotations are from Bendyshe's translation. From p. 386:

... For either our explanations are idle and futile, or many properties which have been acquired by the parent are transferred to the offspring. Are they then so transferred? It would certainly seem so. Thus the father begets a son like himself in every way in form of body, expression of countenance, colour of hair, and sound of voice. The temperament too descends from the father to the son. So also peculiar marks long continue to distinguish the same family of men. But this is particularly shown by the history of disorders; of which there are instances known to all in the cases of gout, scrofula, and madness. Again, diarrhoea and unnatural dilations of the arch of the aorta long infest the same family. These diseased conditions must be looked on in the same light as other mutations of the corporeal condition. And to speak of both from the same point of view, surely that change which is the origin of the production of black skin may just as easily be communicated by the parent to its offspring, and is no more difficult to explain, than that by which gout is handed down in the same way. Nor is it at all more difficult to understand, why the skin begins to grow black a certain time after birth, than why some years afterwards the offspring of scrofulous parents is infested with ulcers.

Still all the same it is a fact which we cannot explain; and yet there is no manner of doubt that peculiarities acquired by men do descend to their posterity.

Thus the fact being once established, it will be no longer obscure why men undergo, from the causes induced, such great changes of colour, stature, and the other matters we have mentioned. The black colour of the parent may become blacker in the son, if he is exposed to the same external influences, and so in the course of ages may approach more and more to actual blackness; and in that way at last great effects may flow from causes so small as to escape notice, if each generation contributes something to increase them.

Why one form of appearance and countenance becomes permanent in one nation, and one in another, is explained by this, that parents always produce offspring like themselves.

It would however be difficult to say, how many centuries it takes to change the skin from white to black, or in any other way. But if we may conjecture at all from the sudden effect of the sun and the air in changing the skin, a long time is not necessary. But that Europeans who inhabit hot regions do not acquire even after a very long time

a brown or black colour, and that negroes after being a long time in Europe do not grow white, may be for this reason; that the former never try those modes and ways of life, and other external circumstances, which we have said are so powerful in effecting change; and if they do suffer from necessity or adverse fortune, then they do change colour and that the latter wretched mortals never are able to enjoy this easy kind of life, by which whiteness is so greatly brought about. . . .

Thus then the question, how those marks which distinguish individuals may be transferred from parents to their children, is answered. And now recurs the other, how those marks differ from the ones which are not so transferred, and what is the reason why some marks peculiar to the parents are transferred, and others are not. I must confess this is one I cannot answer. For the Creator has hidden the business of generation in the deepest recesses of nature, and has kept all its processes sunk and overwhelmed in the deepest darkness, never perhaps to be brought to light. And therefore to explain things depending upon such a cause would be a vain and idle undertaking. . . .

I indeed am unwilling to appear to compel all nature to my opinion; but these observations, as they show that diversity of species is not necessary for causing blackness of colour, and that this property, like others, may be acquired through external circumstances, and so descend from father to son, so also do they in some way confirm the doctrine about colour I have laid down. . . .

It is a question also whether any peculiar conditions of this brain, affecting the mind, can be handed down from parent to son? It has been said above that temperament at all events is so communicated. But different temperaments are so connected with different tones and conditions of mind, that, in common parlance, they are referred to mind alone. Therefore, if certain conditions of the brain, from which some operations of the mind proceed, are transmitted by the accident of birth, what is to prevent the peculiar condition of that part of the brain, which is appropriated to reason, being transmitted in a similar way? And this will appear much more probable to one who considers that a diseased condition, like that of madness, is propagated from father to son in the same family for generations.

A month or so after the publication of John Hunter's paper, which has just been cited, JOHANN FRIEDRICH BLUMENBACH, one of the eighteenth-century founders of the science of comparative anthropology, published *De generis humani varietate nativa* (Göttingen, 1775). In this first edition he adopted the orthodox anthropological view, that acquired characters were heritable. Thomas Bendyshe also translated this essay into English and included it in *The anthropological treatises of Johann Friedrich Blumenbach*, London, 1865. The following quotations are from this edition. From p. 116:

There is a passage in Hippocrates about the skulls of the Scythians, which is most worthy of notice. He says that after they had applied artificial means for a very long period in shaping their heads, at last a kind of natural degeneration had taken place, so that in his day there was no more necessity for manual pressure to arrive at the end in view; but that the skulls grew up to be elongated of their own accord. And this kind of thing should be examined in other varieties of mankind, especially as to form and colour, and their various causes, climate, &c., which in the

progress of time become hereditary and constant, although they may have owed their first origin to adventitious causes.

From p. 121:

So much then about the shape of skulls. From what has been said I trust that it is more than sufficiently clear, that almost all the diversity of the form of the head in different nations is to be attributed to the mode of life and to art: although I should very willingly admit the position of Hippocrates, that with the progress of time art may degenerate into a second nature, since it has a very considerable influence in all the other variations of mankind.

By the time the third edition appeared in 1795, however, Blumenbach was assailed by doubts. Nevertheless, he still strongly leaned toward the view he had expressed earlier. From p. 196:

But the mixture of specifically different generation, although it cannot overturn, or as it were suffocate, all the excitability of the formative force, still can impart to it a singular and anomalous direction. And so it happens that the continuous action, carried on for several series of generations of some peculiar stimuli in organic bodies, again has a great influence in sensibly diverting the formative force from its accustomed path, which deflection is the most bountiful source of degeneration, and the mother of varieties properly so called. So now let us go to work and examine one by one the chief of these stimuli.

He discussed the possible inheritance of mutilations at length. From p. 203:

39. *Problem proposed. Can mutilations and other artifices give a commencement to native varieties of animals?* It is disputed whether deformities or mutilations, effected upon animals either by accident or advisedly, especially in those cases where they have been repeated for many series of generations, can at length in progress of time terminate in a sort of second nature, so that what before was done by art now degenerates into a congenital conformation. Some have asserted this, whilst others on the contrary have denied it. Those who are for the affirmative point to the examples of the young of different kinds of animals, dogs and cats for example, which are born without tails or ears after those parts have been cut off from their parents, as is proved by credible witnesses. And of boys among circumcised nations who are frequently born naturally apellae; and of scars which parents bear from wounds, whose marks afterwards are congenital in the infants. Buffon, indeed, went so far as to derive from the same source the peculiar characters of some animals, as the callosities on the breast and legs of camels, or the bald scurfy forehead of the rook (*Corvus frugilegus*). Those who do not allow these last instances will not unwisely reject this opinion of Buffon, as what is called a *petitio principii*; but the other instances we spoke of they will think should be rather attributed to chance.

I have not at present adopted as my own either the affirmative or the negative of these opinions; I would willingly give my suffrage with those on the negative side, if they could explain why peculiarities of the same sort of conformation, which are first made intentionally or accidentally, cannot in any way be handed down to descendants, when we see that other marks of race which have come into existence from other causes which up to the present time are unknown, especially in the face, as noses, lips, and eye-brows are universally propagated in families for few or many generations with less or greater constancy,

just in the same way as organic disorders, as deficiencies of speech and pronunciation, and such like; unless perhaps they prefer saying that all these occur also by chance. . . .

The more causes of degeneration which act in conjunction, and the longer they act upon the same species of animals, the more palpably that species may fall off from its primeval conformation. Now no animal can be compared to man in this respect, for he is omnivorous, and dwells in every climate, and is far more domesticated and far more advanced from his first beginnings than any other animal; and so on him the united force of climate, diet and mode of life must have acted for a very long time.

From p. 212:

Now the aboriginal Ethiopians have been for a long time and for many series of generations exposed to the action of that climate, since they must without doubt be ranked amongst the most ancient nations of the world. So we must not be surprised if they propagate unadulterated, even under another climate to succeeding generations, the same disposition which has spread such deep and perennial roots in their ancestors from the most distant antiquity. But, on the other hand, from this tenacity and constancy of constitution of the Ethiopians, this comes out all the clearer, that such a power can only be contracted after a long series of generations, and so it must be considered as a miracle, and against all natural law, if it be true, what we find frequently related that the present descendants of some Portuguese colonists who emigrated to Guinea in the 15th century, have in so short an interval of time, through the influence of the climate, been able to contract the Ethiopian habit of body.

Meanwhile in his *Institutiones physiologicae* (1787), he had definitely accepted the heritability of mutilation. The following quotation is from the English edition *Elements of physiology*, Philadelphia, 1795:

It is necessary further to observe, that not only monstrosities co-eval with the birth of animals, but also subsequent adventitious mutilations and other species of deformity, whether produced on the animal system by accident or design, become now and then completely hereditary; and thus, what at first the effect of art alone, may be said to become at length the actual work of nature herself.

As the eighteenth century went into its final quarter, descriptions of the inheritance of acquired characters were coming thick and fast. It is interesting for us to note how many of Lamarck's contemporaries stated that such characters were inherited and to note how completely these statements have been overlooked by modern biologists. Indeed, during this period records of the inheritance of acquired characters are to be found in the most unexpected places, in works on many subjects, biological, anthropological, medical, travel, and adventure stories, popular histories, etc. It was the accepted doctrine.

When Captain James Cook traveled around the world in His Majesty's sloop, *Resolution*, he took with him the Forsters, father and son. Both Forsters wrote books and both described the inheritance of acquired characters.

JOHN REINHOLD FORSTER, the father, published *Observations made during a voyage round the world*,

London, 1778, a year after his son's book had appeared. The following passages are taken from p. 272-273:

. . . it is therefore evident, that if climate can work any material alterations, it must require an immense period of time to produce it. . . . It must, however, be observed, that when the fair Northern nations are removed into the hot tropical climates, they themselves and their progeny now change, and gradually become somewhat more analogous in colour, and other circumstances to the former inhabitants. . . . for if two Europeans, equally fair, are removed to the same hot climate, and the one is well dressed, and avoids as much as possible, being exposed to the action of the air, and power of the sun; while the other finds himself obliged to work in the open air, and has hardly any rags to cover his skin; they will, of natural consequence, become widely different in colour; moreover, if this diversity in the mode of living be kept up for several generations, the character of both must of course become more strikingly different.

GEORGE FORSTER, the son, published *A voyage round the world*, London, 1777. During his trip he found it expedient to eat a dog, an experience which gave rise to the following philosophical reflection. From vol. I, p. 235:

But it is owing to the time we spend on the education of dogs, that they acquire those eminent qualities which attach them so much to us. The natural qualities of our dogs may receive a wonderful improvement, but education must give its assistance without which the human mind itself, though capable of an immense expansion, remains in a very contracted state. In New Zealand and (according to former accounts of voyages) in the tropical isles of the South Sea, the dogs are the most stupid, dull animals imaginable, and do not seem to have the least advantage in point of sagacity over our sheep, which are commonly made the emblems of silliness. In the former country they are fed upon fish, in the latter on vegetables, and both these diets may have served to alter their disposition. Education may perhaps likewise graft new instincts. . . .

From p. 243:

The New Zealand dog, mentioned above, which devoured the bones of the roasted dog, now fell upon the dead puppy, and ate of it with a ravenous appetite. This is proof how far education may go in producing and propagating new instincts in animals. European dogs are never fed on the meat of their own species, but rather seem to abhor it. The New Zealand dogs, in all likelihood, are trained up from their earliest age to eat the remains of their master's meals; they are therefore used to feed upon fish, their own species, and perhaps human flesh; and what was only owing to habit at first, may have become instinct by length of time. This was remarkable in our canibal-dog, for he came on board so young, that he could not have been weaned long enough to acquire a habit of devouring his own species, and much less of eating human flesh; however, one of our seamen having cut his finger, held it out to the dog who fell to greedily, licked it, and then began to bite into it.

Having traveled around the world and seen many races of man, Forster naturally had much to say concerning the origin of human races. In *Noch etwas über die Menschenrassen* published in *Der teutsch Merkur* IV: 57-86, 1786, he stated on page 70:



Entirely otherwise is the all pervading influence of climate which requires many generations before it becomes visible and noticeable. The progress is slow but continuous. The later grandchildren of white settlers in warm countries have a darker color and become finally black in the course of centuries in the torrid zone. On the other hand when negroes pass the boundary of the tropics their descendants lose their black color: they become dark brown, olive colored and perhaps—for can we here not trace an ultimate probability?—a lighter color the further they leave the equator behind, and inhabit a milder zone.

Later, in *Ein Beytrag zur Völker-und Länderkunde, usw.*, Leipzig 1789, Forster stated (as cited by Voight) :

One has noticed in England that they have cut continuously the tails of the horses, and were treated in the same manner for many generations. Eventually colts were born with short tails.

E. A. W. VON ZIMMERMAN published *Geographische Geschichte des Menschen*, Leipzig, 1778–1783. Here he called upon the inherited modification caused by climate to explain the existence of different human races. From vol. I, p. 97 :

From the foregoing this much is definite, that the most important fluids in the negro are colored. Yet if the sperm itself is colored, how can one expect that this substance, which modifies the inner man only after many years, should after several generations be quickly driven away or obliterated through the opposite operation? If it takes a number of generations to transform a white man into a negro, then I am convinced that a much longer period is required to make the negro white again. Everyone knows how quickly a brownish-red spot appears on the skin when one burns oneself, and how long it takes in comparison to get rid of this redness. Although, to be sure, the heat of the sun affects the negro differently from the way fire affects one when one is burnt,—nevertheless, the comparison brought up here is not entirely unjustifiable, for in both cases something similar takes place. All permeable bodies, Herr von Paw tells us, acquire coloring more easily than they lose it again. It is therefore not at all unconceivable to me that the negroes of Pennsylvania, which is not a very cold place yet, would require a long time to get rid of their burnt-in black pigment. Meanwhile Demanent maintains that the negroes living in Europe, especially those born in the American colonies or in Europe, are far less dark than the negroes in their chief abode in Sengal and Guinea. Hence it is still a question whether the present-day negroes of Pennsylvania are actually as jet black as their ancestors. To ascertain accurately the time and number of generations necessary to transform a tribe of blacks from Senegal into northern whites, one would need to transport them not to Pennsylvania or to France but to Denmark or Gothland. Then they would have to be exposed to the open air as much as possible, prevented from mingling with whites, and given a diet completely in accordance with the northern climate. Then I am quite assured that such a transformation, although slowly, could and would actualize. But just for this reason negroes which are brought over from their hot climate to a warm one could hardly change at all. The examples of the Papuans in New Guinea and the islands around there are proofs.

JOHANN GOTTFRIED HERDER started the publication of his famous *Ideen zur Philosophie der Geschichte der*

*Menschheit* in 1784. Here he described the struggle for existence and the extinction of species which were not able to adapt themselves to new conditions. He recognized that new varieties arose at times and that even among human beings racial modification would occur and that these modifications made for fitness. He distinguished very clearly between transient adaptation to environmental peculiarities and deep-seated genetic changes. In the following passage he seemingly denies the inheritance of acquired characters. From the English translation, *Outlines of the philosophy of the history of man* I: 324, London, 1803 :

The various national forms of people however, testify, that even this, the most difficult change of the human species, is possible: and it is rendered so by the multifarious complication and delicate mobility of our frame, with the innumerable powers that act upon it. But this difficult change is effected only from within. For ages particular nations have moulded their heads, bored their noses, confined their feet, or extended their ears: Nature remains true to herself; and if for a time she be compelled to take a course she would not, and send fluids to the distorted parts; she proceeds on her own way, as soon as she can recover her liberty, and produces her own more perfect image. If the deformity be genetic, and effected in the natural way, the case is totally different: it is then hereditary, even in particular parts. Let it not be said, that art or the Sun has flattened the negro's nose. As the figure of this part is connected with the conformation of the whole skull, the chin, the neck, the spine; and the branching spinal marrow is as it were the trunk of a tree, on which the thorax and all the limbs are formed; comparative anatomy satisfactorily shows, that the degeneration has affected the whole figure, and none of these solid parts could be changed without an alteration of the whole. Thus the negro form is transmitted in hereditary succession, and is capable of being rechanged no otherwise than genetically. See the negro in Europe: he remains as he was. Let him marry a white woman, and a single generation will effect a change, which the fair-complexioned climate could not produce in ages. So it is with the figures of all nations; regions alter them very slowly; but by intermixture with foreigners, in a few generations every mungal, chinese, or american feature vanishes.

For us to understand Herder's real ideas we must consider his essential mysticism. Nature is always personified and is supposed to have definite intentions. Even if she struggled against crude unnatural deformations she could be influenced in the end by means which were not clearly specified. Herder believed, "That diseases and features, nay the tempers and dispositions, are hereditary, is known to all the world": Such an all pervading force as climate would sooner or later create new varieties. In the following passage (p. 330) he practically indorses the inheritance of acquired characters :

Climate is a chaos of causes, very dissimilar to each other, and in consequence acting slowly and in various ways, till at length they penetrate to the internal parts, and change them by habit, and by the genetic power itself; this resists long, forcibly, uniformly, and like itself, but as it is not independent of external affections, it also must accommodate itself to them in length of time.

IMMANUEL KANT was outspoken in his opposition to a belief in the inheritance of acquired characters and thus he belongs in the small group which included, up to this time, Lucretius, Vincent of Beauvais, Bonnet, and Lord Kames. In his *Bestimmung des Begriffs einer Menschenrace*, first published in the *Berlinische Monatsschrift* (6: 390) in 1785, he stated the theory only to refute it, although his refutation was based entirely upon *a priori* grounds. In Number 5 he stated (the translation is very free):

The inheritance through the working of the imaginative powers of pregnant women or even of mares at stud; the forcing of nature to omit gradually a product of her generation by the plucking out of the beards of whole tribes and by the cropping of the tails of English horses; the flattened noses, which had originally been bestowed with great pains by parents on their children, had consequently been given by the generative forces of nature; these and other explanations would scarcely be proven by the facts tending to substantiate them, for one can much better prove the contrary true, if they did not receive the reason for their existence from the otherwise entirely correct maxim, namely, it is preferable to risk everything in conjecturing from the given phenomena rather than to assume for this purpose special natural forces or innate "Anlage." But I urge another maxim, contrary to the above, which has generally been rejected through the neglect of this principle, namely, that in the entire organization of nature, in spite of all variations, individual creatures of the same species remain essentially unaltered. Now it is clear that if the magic power of development or the experiments of men on animal bodies could bring about the possibility of altering the generative power, one would not know any more from which origin in nature any form may have come, whether the primitive form made by nature had persisted to the present or how far through additions or disfigurements it may have been modified, and, since there are no limits to the human imagination, into what grotesque shape the genera and species might at last grow. According to this consideration I take for my basic postulate, that we cannot admit that the bungling influence of the power of the imagination may affect the natural process of generation, or that any power of man through outer artificial modifications may affect the old original forms of the genera or species.

In SAMUEL THOMAS VON SÖMMERRING'S essay on the physical differences between Europeans and Negroes, he described the cumulative effect of climate. From *Über die körperliche Verschiedenheit des Negers vom Europäer*, 79, Frankfurt und Mainz, 1785:

But if primitive man could now spread from Asia over the whole world, could be enobled to a European or degenerate to a Negro, may I not decide that he was perfected for his climate, for one finds adaptations in the build of the Negro as well as in that of the European.

How many plants loose through their culture the greater part of their native fitness? The forced beauty and size of the past blooms often distorts, perverts or lessens the true function of the flower reproduction, even to destroying the efficiency of the entire plant!

So also with men: the intellect is often cultivated to the disadvantage of the body and, on the contrary, the body to the disadvantage of the mind.

CHRISTOPH MEINERS was not particularly specific nor detailed in his description of environmental influ-

ence. He did believe, however, that human skin color could be altered in any desired direction, and his description implied that such alterations were heritable. From *Grundriss der Geschichte der Menschheit*, 91, Lemgo, 1785:

The chief cause of this is the blood of the parents, and next to the blood, the climate: to a much less extent the food. Dirt alters the appearance of the color, and the manner of living can either increase or diminish the effects of the climate. In spite of this one finds in different and even in the same regions of the Earth men of entirely different color; one can even state very definitely the law according to which the skin of human beings is colored lighter or darker.

SAMUEL STANHOPE SMITH, President of the College of New Jersey, published *An essay on the causes of varieties of complexion and figure in the human species*, Philadelphia, 1787. The following indorsements of the inheritance of acquired characters are taken from the 1810 edition. From p. 35:

It will be of importance to bear in mind throughout this essay, that the causes affecting the physical or moral constitution of man, and ultimately producing great distinctions between nations, seldom attain their full operation till after a long series of time. By almost imperceptible touches they produce their effects, till entering deeply, at length, into the habits and whole structure of our nation, they are transmitted from parents to their offspring. Even several generations may pass away before the ultimate results of the influences either of the climate, of the state of society, or of the manner of living, are perceived.

From p. 45:

. . . Long in growing to maturity, national features, like several manners, become fixed only after a succession of several generations. At last, however, they become fixed. And if we can ascertain any effect produced by a given state of climate, of society, or of habits of living, it requires only to be repeated during a sufficient length of time, to give it a permanent character, and so to incorporate it into the constitution, as to render it an hereditary property of race. The sanguine, or the fair complexion will, for this reason, be perpetual in the higher latitudes of the temperate zone, and we shall generally find different shades of the darker colours, gradually increasing, till we arrive at the perfectly black, as we descend to the equator.

From p. 115:

Camper indeed has produced some very plausible facts for his opinion that the effects of violence upon the body, or of any customs which affect it only externally can never be transmitted by birth. The contrary doctrine, however, has been supported by the great names of Hippocrates, Aristotle, Pliny, and even by those greater naturalists Haller and Buffon (and may now be regarded as settled beyond all controversy.)

From a footnote on p. 130:

Certain it is that neat cattle, horses, and other domestic animals, turned into the woods in the West of Carolina, in Louisiana, and other uncultivated parts of America, where they find but a scanty supply of food, and are liable to many accidents from their feebleness at certain seasons of the year, and the want of human care, not only become diminutive and deformed themselves, but, although brought

back from their wild and savage state, and placed in the most favorable circumstances, will propagate a diminutive and deformed offspring for several generations. By proper attention, however, they are capable of being gradually restored to the size and beauty of the original European stock from which they were derived; except in those places where a hot sun, and barren soil prevent the growth of luxuriant herbage. In such situations, the size of the animal is necessarily contracted in proportion to the defect of nutritious food, or the prevalent excess either of heat, or cold.—

Such examples as the preceding seem to confirm, in some degree, the opinion of Hippocrates, Scaliger, and Cardan, which has been just mentioned, and of other respectable writers, who have embraced the same doctrine,—that any form of the body, or of any of its parts, produced not only by climate or the means or modes of living, but by any habit, the result either of climatical influence like the contracted eyes and forehead of the negro, or of national custom, like the small feet of the females in China, the long heads of the Macrocephali, or the flat heads of some of our indian tribes, is communicable to offspring by natural influence.

HEINRICH JOHANN VOIGT edited the *Magazin für das Neueste aus der Physik und Naturgeschichte*. In volume 6, number 1, page 13 (1789) appeared an unsigned review, “J. Fr. Blumenbach, Über Künstleyn oder zufällige Verstümmelungen am thierischen Körper, die mit Zeit zum erblichen Schlag ausgeartet,” probably written by the editor. The inheritance of mutilations is described as follows (p. 14):

The possibility exists that physical crippling of the animal body especially if repeated through generations in time becomes hereditary and then appear as if from nature. Among many examples of this kind a Spanish bitch, says Hr. Schulz, which has lived for many years in my home is not only by nature without a tail, but she has also several times given birth to puppies among which several were tailless. Everytime she gave birth to more than one puppy there appeared only one with a complete tail, some with half sized tails or still shorter or at least one without a tail. The oddest of this was the fact that these puppies had all the physical characteristics of their father with the single exception of the tail which they had from the mother.

The author next cites the instances of the inheritance of mutilations described by Sir Kenelm Digby and Forster, and then proceeds (p. 22):

The late Hofratl Osam came to me one day quite astonished and told me of a case in a certain family. The father had had the little finger of his right hand crushed in his youth and had healed in a crippled manner, and now all his sons and daughters had a crooked fifth finger on their right hands.

A savant reproached me one day and said that the children of circumcized nations would then be born without a “foreskin” but that did not seem to be the case. . . . I asked a Jew well versed about this matter and received this astounding answer: that it was not a strange occurrence that Jewish children were born with a short “foreskin” and that consequently one had to be very careful in the operation.

In another unsigned article (6 (4): 40) occurs the following:

Before I close I must mention another thing which Hr. Hofratl Blumenbach mentioned: the fact that the women of nations that practice circumcision,—those who follow the Mosaic law and those who follow Mohamed,—often bear children that seem to have been born already circumcised. I have found this to be the case also of two Christian Children . . . and I don't know whether it was caused through an operation of the Phimosi or Paraphimoses of the parents and the condition transplanted upon the offspring or whether it was a mere accident of nature.

The Hebrews when a case of this kind is found call it *Noladmahul* or born circumcised. The Talmud states that the *Noladmahul* need not be circumcised again but only a scratching from the band which supports the “prepuce.”

MARIE JEAN ANTOINE NICOLAS CARITAT, MARQUIS DE CONDORCET is perhaps the most optimistic creature on record. His *Equisse d'un tableau historique des progrès de l'esprit humain*, 1794, was written while he was a fugitive from his fellow revolutionists, and only a short while before he was caught and liquidated. Unfortunate circumstances, however, could not dim his sweetness and light. In 1795 his work was translated into English and published as *Outlines of an historical view of the progress of the human mind*, a work which greatly stimulated Malthus but not, of course, in a direction which would have pleased the author. The inheritance of acquired characters had the appeal for Condorcet that it has for most optimists. From p. 367:

The organic perfectibility or deterioration of the classes of the vegetable, or species of the animal kingdom, may be regarded as one of the general laws of nature.

This law extends itself to the human race; and it cannot be doubted that the progress of the sanative art, that the use of more wholesome food and more comfortable habitations, that a mode of life which shall develop the physical powers by exercise, without at the same time impairing them by excess, in fine, that the destruction of the two most active causes of deterioration, penury and wretchedness on the one hand, and enormous wealth on the other, must necessarily tend to prolong the common duration of man's existence, and secure him a more constant health and a more robust constitution. It is manifest that the improvement of the practice of medicine, become more efficacious in consequence of the progress of reason and the social order, must in the end put a period to the transmissible or contagious disorders, as well as to those general maladies resulting from climate, ailments, and the nature of certain occupations. Nor would it be difficult to prove that this hope might be extended to almost every other malady, of which it is probable we shall hereafter discover the most remote causes. Would it even be absurd to suppose this quality of melioration in the human species as susceptible of an indefinite advancement; to suppose that a period must one day arrive when death will be nothing more than effect either of extraordinary accidents, or of the slow and gradual decay of vital powers; and that the duration of the middle space, of the interval between the birth of man and this decay, will itself have no assignable limit?

From p. 370:

But may not our physical faculties, the force, the sagacity, the acuteness of the senses, be numbered among the qualities, the individual improvement of which it will be practicable to transmit? An attention to the different

breeds of domestic animals must lead us to adopt the affirmative of this question, and a direct observation of the human species itself will be found to strengthen the opinion.

Lastly, may we not include in the same circle the intellectual and moral faculties? May not our parents, who transmit to us the advantages or defects of their conformation, and from whom we receive our features and shape, as well as our propensities to certain physical affections, transmit to us also that part of organization upon which intellect, strength of understanding, energy of soul or moral sensibility depend? Is it not probable that education, by improving these qualities, will at the same time have an influence upon, will modify and improve this organization itself? Analogy, an investigation of the human faculties, and even some facts, appear to authorize these conjectures, and thereby to enlarge the boundary of our hopes.

ERASMUS DARWIN is the one contemporary of Lamarck who used the conception of the inheritance of acquired characters to explain evolution. It is, perhaps, for this reason that modern biologists have remembered his Lamarckianism. Of course, labeling Erasmus Darwin a Lamarckian is wholly unjustified as Darwin anticipated Lamarck by eight years. It would be more appropriate to call Lamarck a Darwinian, but this latter term has two separate meanings already, i.e., (1) an evolutionist and (2) one who believes in Charles Darwin's theory of natural selection. It might be possible for us to distinguish between Erasman Darwinism and Carolian Darwinism but not probable, for we are confused enough as it is, so there is a very real advantage in not altering the more familiar terms now current in the literature of evolution.

Erasmus Darwin published his *Zoonomia; or, the laws of organic life* in 1794. Here in section 39, "Of generation," he describes for the first time his notions of heredity and evolution. Like Lamarck he emphasized the modifications in the animal body caused by the exertion of the animal itself rather than those which were acquired passively as direct effects of the environment. In either case, however, he held that they were inherited. From XXXI, 1:

... Dr. Maningham, a popular accoucheur in the beginning of this century, observes in his aphorisms, that broad shouldered men procreate broad shouldered children. Now as labour strengthens the muscles employed, and increases their bulk, it would seem that a few generations of labour or of indolence may in this respect change the form and temperament of the body.

From XXXIX, 4, 8:

From their first rudiment, or primordium, to the termination of their lives, all animals undergo perpetual transformations; which are in part produced by their own exertions in consequence of their desires and aversions, of their pleasures and their pains, or of irritations, or of associations; and many of these acquired forms or propensities are transmitted to their posterity. . . .

After describing such characteristic adaptive structure as the elephant's trunk, the tusks and claws of the carnivores, the nose of the swine, the rough tongue of

cattle and sheep, and the many different types of beaks in the order, *Aves*, he adds:

All of which seem to have been gradually produced during many generations by the perpetual endeavor of the creatures to supply the want of food, and to have been delivered to their posterity with constant improvement of them for the purposes required. . . .

Darwin then traces in detail the great changes our domestic animals have undergone, changes often so great that, as in the case of several breeds of dogs, their wild ancestors cannot be identified with certainty. He continues:

Add to these various changes produced in the forms of mankind, by their early modes of exertion; or by the diseases occasioned by their habits of life; both of which become hereditary and that through many generations.

Darwin was particularly interested in the question of hereditary disease which he discussed at some length. He had previously described this type of inheritance in his *Phytologia* (1788) and his interest in the subject continued, for there are many such descriptions also in his *Temple of nature* (1802) published after his death.

CHRISTIAN FRIEDRICH LUDWIG evidently accepted the inheritance of acquired characters. In *Grundriss der Naturgeschichte der Menschenspecies*, Leipzig, 1796, he described the slow and gradual changes which occur in human and animal stocks. The inheritance of acquired characters is implied rather than stated. From p. 223:

§326. It has been proven that numerous affective causes can produce a differentiation of the human species the most affective one coition, climate, type of food and customs. The alteration of the original features—both physical and mental—does not take place suddenly but gradually. . . .

§330. Here we must mention some examples of the manifold degeneration in the seminary animal and vegetable creation; Dogs horses . . . tulips and carnations . . . Must we suppose that the picture of the original man has disappeared just as much as that of the originals of domestic animals?

§397. Is it possible that hereditary diseases can give rise to a particular racial differentiation?

The famous WILLIAM GODWIN, who later flinched so markedly from the harsh conclusions reached by Malthus, believed in the inheritance of acquired characters. From *The enquirer*, 22, London, 1797:

That the accidents of body and mind should regularly descend from father to son, is a thing that daily occurs, yet is little in correspondence with the system of our philosophers.

How small a share, accurately speaking, has the father in the production of a son? How many particles is it possible should proceed from him, and constitute a part of the body of the child descended from him? Yet how many circumstances they possess in common?

It has sometimes been supposed that the resemblance is produced by the intercourse which takes place between them after their birth. But this is an opinion which the facts by no means authorize us to entertain.

CHARLES WHITE, who published just two years after Godwin and three years before Lamarck, rejected the inheritance of acquired characters. He believed that all species and varieties were created in the exact form that they possessed in his day. His denial of the inheritance of acquired characters was essentially a denial of evolution. He did, however, believe in a great chain of being, which he described in *An account of the regular gradations in man and in different animals and vegetables and from the former to the latter*, London, 1799. On page 132 he stated that the effects of sunburn were not inherited:

The temporary discolouration of the skin, called tanning, seems to have no relation to the permanent colour of the skin: it arrives at its *maximum* a very short time after it begins, and is soon worn off again; whereas the permanent black colour (supposing, for argument sake, it could be effected in time) must require many centuries to effect it. Thus the father, it is supposed, transmits his degree of colour to the son, and the climate still keeps increasing it; and hence ultimately, from the climate alone, or at least from external circumstances, we are taught to expect the complete change from black to white, or the contrary, in the course of perhaps fifty or a hundred generations.

As to the opinion, that the constitution of man may be adapted to any climate by long residence, it is not only unwarranted by facts, but is in direct opposition to all analogy, drawn from the animal and vegetable kingdoms at large.

##### 5. SOME NINETEENTH CENTURY RECORDS TO THE TIME OF CHARLES DARWIN

We now come in chronological order to LAMARCK himself. Lamarck's *laws* and the absurd illustrations he gave of their workings, which brought his whole doctrine into disrepute, have already been quoted (p. 91). This, however, does not give a picture of Lamarck which is complete enough to be fair. He specifically denied the direct alterations of organisms to fit their environment and, like Erasmus Darwin, thought that the environment merely stimulated the organism to act in a particular way. It was the action which altered the organism (in plants it was nutrition) and it was these alterations which were cumulative from generation to generation. The following quotation is from *Philosophical zoology* 107, London, 1914,

I must now explain what I mean by this statement: *the environment affects the shape and organization of animals*, that is to say that when the environment becomes very different, it produces in course of time corresponding modifications in the shape and organisation of animals.

It is true if this statement were to be taken literally, I should be convicted of an error; for, whatever the environment may do, it does not work any direct modification whatever in the shape and organisation of animals.

But great alterations in the environment of animals lead to great alterations in their needs, and these alterations in their needs necessarily lead to others in their activities. Now if the new needs become permanent, the animals then adopt new habits which last as long as the needs that evoked them. This is easy to demonstrate, and indeed requires no amplification.

It is then obvious that a great and permanent alteration in the environment of any race of animals induces new habits in these animals.

Now, if a new environment, which has become permanent for some race of animals, induces new habits in these animals, that is to say, leads them to new activities which become habitual, the result will be the use of some one part in preference to some other part, and in some cases the total disuse of some part no longer necessary.

Nothing of all this can be considered as hypothesis or private opinion; on the contrary, they are truths which, in order to be made clear, only require attention and the observance of facts.

We shall shortly see by the citation of known facts in evidence, in the first place, that new needs which establish a necessity for some part really bring about the existence of that part, as a result of efforts; and that subsequently its continued use gradually strengthens, develops and finally greatly enlarges it; in the second place, we shall see that in some case, when the new environment and the new needs have altogether destroyed the utility of some part, the total disuse of that part has resulted in its gradually ceasing to share in the development of the other parts of the animal; it shrinks and wastes little by little, and ultimately, when there has been total disuse for a long period, the part in question ends by disappearing. All this is positive; I propose to furnish the most convincing proofs of it.

In plants, where there are no activities and hence no habits, properly so-called, great changes of environment none the less lead to great differences in the development of their parts; so that these differences cause the origin and development of some, and the shrinkage and disappearance of others. But all this is here brought about by the changes sustained in the nutrition of the plant, in its absorption and transpiration, in the quantity of caloric, light, air and moisture that it habitually receives; lastly, in the dominance that some of the various vital movements acquire over others.

Among individuals of the same species, some of which are continually well fed and in an environment favorable to their development, while others are in an opposite environment, there arises a difference in the state of the individuals which gradually becomes very remarkable. How many examples I might cite both in animals and plants which bear out the truth of this principle! Now if the environment remains constant, so that the condition of the ill-fed, suffering or sickly individuals becomes permanent, their internal organisation is ultimately modified, and those acquired modifications are preserved by reproduction among the individuals in question, and finally give rise to a race quite distinct from that in which the individuals have been continuously in an environment favourable to their development.

With the work of Lamarck we could very logically bring to an end this early history of the doctrine which we now call Lamarckian. Several aspects of the subject, however, would of necessity be left incomplete, particularly the "provisional hypothesis of pangenesis" which has been the most consistently offered explanation of Lamarckian inheritance. This hypothesis did not receive the name it now has until 1868 when Charles Darwin published his famous chapter on the subject in *The variations of animals and plants under domestication*. In fact, pangenesis and the inheritance of acquired characters are so interdependent that neither can be treated really adequately without the other.

With the publication of Lamarck's *Philosophie zoologique*, however, the subject of the inheritance of acquired characters was placed on a new basis. From this time on it was definitely connected with the theory of evolution, although the connection was not universally made until after Darwin's *Origin of species* appeared in 1859. Prior to this, during the first half of the nineteenth century, scientists could, without violating sound scientific standards, believe that acquired characters were heritable, and yet deny that they would accumulate to a point where they would produce new species. In fact during this period the heritability of acquired characters was much more widely accepted than evolution. On the other hand, some scientists, who seemed to be groping toward a conception of natural selection, indorsed evolution but rejected Lamarck's explanation.

JAMES COWLES PRICHARD published a very famous dissertation *De generis humani varietate* in 1808. This was translated into English and published as *Researches into the physical history of man* (1813). In the second edition issued in 1826, Prichard showed that he had a very clear and, from our modern point of view, a very accurate idea of evolution. He almost anticipated the hypothesis of natural selection, but, in subsequent editions, he became more and more absorbed in the minutiae of his subject and more or less indifferent toward its evolutionary aspects. In his earlier editions, however, he distinguished very clearly between congenital and acquired characters and denied the inheritance of the latter. From p. 194 ff, ed. of 1813:

It appears that the principle in the animal economy on which the production of varieties depends is entirely distinct from that which regards the changes produced by external causes on the individual.

These two classes of phenomena are governed by very different laws. In the former instance certain external powers acting on the parent, influence them to produce an offspring possessing some peculiarities of form, colour, or organization, and it seems to be the law of nature that whatever characters thus originate, become hereditary, and are transmitted to the race, perhaps in perpetuity. On the contrary, the changes produced by external causes in the appearance or constitution of the individual, are temporary, and in general acquired characters are transient, and have no influence on the progeny. . . .

The truth of the other proposition advanced, that no acquired characters are ever transmitted, is not so immediately evident, although it appears to be universally confirmed by experience. It may be stated as a general fact, that the organization of the offspring, allowing still a certain range for the springing up of new varieties, is always formed on the model of the natural and original constitution of the parent, and is not affected by any change the latter may have undergone, or influenced by any new state it may have acquired. . . .

. . . All nations are subject to accidental injuries, and amputations and other operations of surgery have been practiced in every country, from immemorial time. Yet who ever heard of any effect produced on the race? Our horses and other domestic animals are continually mutilated in their ears and tails, from our caprice. An infinite

number of decisive experiments are performed every day with the same results.

It has been said that after any operation has been repeated during many generations, a sort of habit may be acquired, by which the new state becomes as it were natural, and may thus affect the race. But the principle of habit cannot be called into existence in this case, where the violence committed and the injury suffered in every successive generation is not less than it was at first. But if an instance be wanting to prove that repetition effects no difference in the results, we have one in the Jews, and in the other nations who have practiced circumcision invariably during many thousand years, yet the artificial state has not become natural. . . .

We cannot discern any essential circumstance in which changes produced by art, or by casual injury, differ from those which are effected by other external causes. Neither do the latter appear to be communicable to the offspring, which is always formed according to the natural constitution of the parent.

We endeavoured in the first instance to shew that there is no foundation for the common opinion which supposes the black races of men to have acquired their colour by exposure to the heat of a tropical climate during many ages. On the contrary the fact appears to be fully established, that white races of people migrating to a hot climate, do preserve their native complexion unchanged, and have so preserved it in all the examples of such migration which we know to have happened. And this fact is only an instance of the prevalence of the general law, which has ordained that the offspring shall always be constructed according to the natural and primitive constitution of the parents, and therefore shall inherit only their connate peculiarities and not any of their acquired qualities. It follows that we must direct our inquiry to the connate varieties, and to the causes which influence the parents to produce an offspring deviating in some particulars of its organization from the established character of the stock.

WILLIAM LAWRENCE, like Prichard, believed in evolution but not in the inheritance of acquired characters. In his *Lectures on the natural history of man* (1819) he seemed to play all around the idea of natural selection but always just managed to miss it. He clearly distinguished between acquired and congenital characteristics. From p. 467, ed. of 1822:

The change in the colour of the human skin, from exposure to sun and air, is obviously temporary; for it is diminished and even removed, when the causes no longer act. The discolouration, which we term tanning, or being sun-burnt, as well as the spots called freckles, are most incidental to fair skins, and disappear when the parts are covered, or no longer exposed to the sun. The children of the husbandman, or of the sailor, whose countenance bears the marks of other climes, are just as fair as those of the most delicate and pale inhabitants of the city: nay, the Moors, who have lived for ages under a burning sun still have white children; and the offspring of Europeans in the Indies have the original tint of their progenitors. . . .

It is obvious that the external influences just considered, even though we should not allow them to a much greater influence on individuals than experience warrants us in admitting, would be still entirely inadequate to account for those signal diversities which constitute differences of race in animals. These can be explained only by two principles already mentioned; namely the occasional production of an offspring with different characters from those of the parents, as a native or congenital variety; and the propaga-

tion of such varieties by generation. It is impossible, in the present state of physiological knowledge, to show how this is affected; to explain why a gray rabbit or cat sometimes brings forth at one birth, and from one father, yellow, black, white, and spotted young; why a white sheep sometimes has a black lamb; or why the same parents at different times have leucaethiopic children, and others with the ordinary formation and characters.

SIR CHARLES LYELL'S contribution to the theory of evolution is well known. Even before his friend, Charles Darwin, conceived of natural selection he held that new forms of life were constantly coming into being, although in his *Principles of geology*, London, 1832, he emphasized the lack of actual evidence for this transmutation of species. In fact, he was extremely critical of Lamarck's easy acceptance of evolution and ridiculed mildly Lamarck's unfortunate illustrations of species changes. In the same work, however, he accepted the inheritance of acquired instincts and to a certain extent out-Lamarcked Lamarck. From vol. II, p. 40, ed. of 1833:

*Acquired instincts of some animals become hereditary.*—It is undoubtedly true, that many new habits and qualities have not only been acquired in recent times by certain races of dogs, but have been transmitted to their offspring. But in these cases it will be observed, that the new peculiarities have an intimate relation to the habits of the animal in a wild state, and therefore do not attest any tendency to departure to an indefinite extent from the original type of the species. A race of dogs employed for hunting deer in the platform of Santa Fe, in Mexico, affords a beautiful illustration of a new hereditary instinct. The mode of attack, observes M. Roulin, which they employ, consists in seizing the animal by the belly and overturning it by a sudden effort, taking advantage of the moment when the body of the deer rests only upon the fore-legs. The weight of the animal thus thrown over, is often six times that of its antagonist. The dog of pure breeds inherits a disposition to this kind of chase, and never attacks a deer from before while running. Even should the latter, not perceiving him, come directly upon him, the dog steps aside and makes his assault on the flank; whereas other hunting dogs, though of superior strength and general sagacity, which are brought from Europe, are destitute of this instinct. For want of similar precautions, they are often killed by the deer on the spot, the vertebrae of their neck being dislocated by the violence of the shock.

A new instinct has also become hereditary in a mongrel race of dogs employed by the inhabitants of the banks of the Magdalena almost exclusively in hunting the white-lipped pecari. The address of these dogs consists in restraining their ardour and attaching themselves to no animal in particular, but keeping the whole herd in check. Now, among these dogs some are found, which, the very first time they are taken to the woods, are acquainted with this mode of attack; whereas, a dog of another breed starts forward at once, is surrounded by the pecari, and, whatever may be his strength, is destroyed in a moment.

Some of our countrymen, engaged of late in conducting the principal mining associations in Mexico, carried out with them some English greyhounds of the best breed to hunt the hares which abound in that country. The great platform which is the scene of sport is at an elevation of about nine thousand feet above the level of the sea, and the mercury in the barometer stands habitually at the

height of about nineteen inches. It was found that the greyhounds could not support the fatigues of a long chase in this attenuated atmosphere, and before they could come up with their prey, they lay down gasping for breath; but these same animals have produced whelps which have grown up, and are not in the least degree incommode by the want of density in the air, but run down the hares with as much ease as the fleetest of their race in this country.

Some of the early nineteenth-century evolutionists also accepted the heritability of acquired characters although they could not quite indorse Lamarck *in toto*. One of these is the generally overlooked SAMUEL STEDMAN HALDEMAN, who collected evidence which indicated that species evolved. He also came very close to a conception of natural selection. His indorsement of the inheritance of acquired characters was published in "Enumeration of the recent freshwater molluscs which are common to North America and Europe; with observations on species and their distribution," *Boston Jour. Nat. Hist.* 4: 468-484, 1844. He stated (p. 472), "The Lamarckian hypothesis of appentency, as he left it, seems clearly untenable, but, in a modified form, affords room for further discussion." He stated further that developmental use could produce only organs which were already created in the germ, but that once an organism was modified it transmitted its modification to its progeny. Another evolutionist who accepted the inheritance of acquired characters was Robert Chambers, whom we need not quote directly. He indicated his belief in numerous passages in the *Vestiges of Creation* published anonymously in 1844.

In spite of the fact that Lamarck at this time enjoyed general disrepute, many scientists continued to find the conception of the inheritance of acquired characters very useful. For example, Prof. J. L. CABELL of the University of Virginia used it to explain the fact that certain races were immune to particular diseases. Incidentally, he also recognized the fact that spontaneous mutations would give rise to new varieties. From *The testimony of modern science to the unity of mankind*, 20, New York, 1859:

. . . But inasmuch as certain acquired peculiarities are often reproduced with perfect regularity so as to give rise, within the limits of a single original species, to "varieties" marked by characters as "*permanenti*" as those which distinguish the species itself, it is obvious that unless the historical records extend back to such a period as wholly to preclude the idea of the appearance of the variations between the first creation of the species and the date of the records, they furnish no satisfactory test whatever. . . . Thus, by carefully changing the food and other agents of vital stimulation, we may modify, to an extent sometimes quite considerable, the outward structural character of many plants and low animal organisms; and these newly acquired characters may then be perpetuated by hereditary transmission, under the influence of the law of assimilation between parent and offspring, even though the causes which originally determined the variation from the primitive type have ceased to operate. A similar effect is produced in those cases in which a given variation appears accidentally in a single individual and is then transmitted to his offspring. . . .

From p. 36:

We may, then, regard it as an established fact that under the influence of causes sometimes appreciable, though often quite unknown, animals may acquire structural characters, differing in many respects from those of the parent stock, and then transmit such peculiarities to their own offspring with entire constancy, so as to give rise to a new breed. It is interesting to remark that not only are the *structural* characters of animals of the same original stock liable to undergo variations, accidental in their origin, yet afterwards regularly transmitted to their offspring, but that the same may be predicated of certain physiological and psychological traits; although the limits of possible departure from the typical characters of the original stock are doubtless more narrow in respect to these qualities, than they are in respect to bodily conformation. . . .

We may remark, in passing, that this tendency to the regular transmission to offspring of characters acquired by the progenitors of a stock, in the gradual process of acclimatisation, furnishes an entirely satisfactory explanation of the alleged immunity enjoyed by our negroes from attacks of yellow fever and malarious diseases. The phenomenon is but another instance of the general principle which has just been stated.

HERBERT SPENCER (1864) almost anticipated Darwin's hypothesis of pangenesis (p. 144) and in so doing he stated, "It involves a denial of the persistence of force to say that A may be changed into A<sup>1</sup>, and yet may beget offspring exactly like those it would have begotten had it not been so changed." Finally, in 1868, DARWIN'S famous chapter on Pangenesis appeared in his *Variation of animals and plants under domestication* and in this work Darwin showed that he had developed into a complete Lamarckian.

Darwin's personal development in this respect is interesting. There is little doubt but that the value he placed upon his own work was very different from the value placed on it by his contemporaries and from the value we place upon it today. Prior to the publication of the *Origin of species*, he looked upon his contribution toward establishing evolution as routine labor, and thought that his real, original gift to the scientific world lay in his ability to explain evolution by natural selection. We have evidence of this in his letter to Sir Charles Lyell written just after he had received Alfred Russell Wallace's essay, *On the tendency of varieties to depart indefinitely from the original type*. Wallace had derived a theory of natural selection independently, and Darwin, under somewhat of an emotional strain wrote, "So all of my originality, whatever it may amount to, will be smashed, though my book, if it ever have any value, will not be deteriorated, as all the labor consists in the applications of the theory."

Darwin's attitude was not unreasonable. At the time evolution was in disrepute in spite of Lamarck's contribution and in part because of Lamarck. Evolution needed an explanation which would be logical and which would make it understandable, and natural selections furnished such an explanation. Lamarck's hypothesis was obviously unsatisfactory. Widespread as

was the belief in the inheritance of acquired characters, Lamarck had made the application of it to evolution a touch ridiculous. At the time, he was obviously no asset to the evolutionists and Darwin had expressed only contempt for him. In 1844, the very year he composed his preliminary essay on evolution, he wrote to Hooker, "Heaven forbid me from Lamarck's nonsense!" The same year he wrote of Lamarck's book as "veritable rubbish" (*Life and letters*).

Shortly after the publication of the *Origin of species*, however, the matter stood in another light. The battle was joined on the question of evolution itself, and not on the validity of natural selection. The publicity which the *Origin* aroused brought to light the fact that Darwin was not the first to explain evolution by natural selection. Both Wells (1813) and Matthews (1831) had anticipated him. With the emphasis shifted to the fact of evolution, Lamarck became a potential ally, especially as Lamackian inheritance could account for a number of observations which could not be explained by natural selection as it was then understood. But the inheritance of acquired characters itself needed a *modus operandi* and Darwin imagined one and called it "pangenesis."

## II. PANGENESIS

The "provisional hypothesis of pangenesis" as it was formulated by Darwin, has been cited (p. 92). In brief, Darwin believed that the cells of the body produce minute granules or atoms, which circulate through the body and, when properly nourished, reproduce by self-division. These particles or gemmules pass into the semen and ultimately produce the cells of the next generation. Of course this hypothesis is the very antithesis of Weismann's conception of the separation of the body and germ plasma and of the latter's continuity from generation to generation. Darwin's hypothesis, unlike Weismann's, suggests a physical mechanism for the transmission of abnormalities from parent to offspring. It also provides a naïvely reasonable explanation of the observed facts of inheritance itself. Furthermore, it renders intelligible one of the real puzzles which faced the earliest philosophers, that of the ability of the parental bodies to generate their like in miniature. If each part of the body contributed a fraction of itself to the semen, it would be necessary only to bring these contributions together and arrange them in the proper order to secure a replica of the parents, tiny but complete.

Darwin described the hypothesis in detail. Many of the earlier philosophers had stated merely that the seed comes from all parts of the body, a description of pangenesis, but pangenesis in a simplified form. This derivation of semen from the whole body is the real essence of the doctrine, the added details but elaborations added to the basic theme. In fact, during the centuries when pangenesis held sway, these elaborations took a number of different forms without in any way altering the im-



plications of the doctrine itself. One of the more popular of these earlier developments of the hypothesis is generally ascribed to the naturalist, BUFFON.

Buffon was of the opinion that immature organisms grew through the intimate penetration of their different parts by organic molecules derived from their food, each molecule being analogous to the part to which it was joined. Prior to maturity there was no superfluity of these organic molecules, but when growth slowed down or stopped, the excess molecules passed on to the semen where, properly organized, they formed the primordia for a new body. In commenting on Buffon's views, Darwin stated, "If Buffon had assumed that his organic molecules had been formed by each separate unit throughout the body, his view and mine would have been very closely similar." It is interesting for us to note that as late as 1883 WILLIAM KEITH BROOKS accepted the hypotheses of both Darwin and Buffon, and stated in *The laws of heredity* (p. 85),

The mode of origin and transmission of the gemmules is essentially like Darwin's conception, and we must acknowledge that Buffon's view of the part played by his organic molecules was very near the truth.

However, there was a very real difference in the views of Buffon and Darwin, a difference which meant more to the medieval schoolmen than it does to the modern biologist. We have only to read the careful arguments of St. Thomas Aquinas and St. Albertus Magnus to realize how important this difference was. Of course, these thirteenth-century philosophers had no observational basis for their views, but they brought together all of the available data in an attempt to determine whether the semen was actually manufactured by all parts of the body or whether it was composed of the proper substances, derived from the excess food which the various parts of the body separated and digested and transmitted to the testes.

#### 1. RECORDS FROM THE BEGINNING TO THE THIRTEENTH CENTURY

In the *Papyrus Ebers*, compiled in 1550 B.C. from still older sources, we find a description of human anatomy which makes the derivation of semen from all parts of the body a very simple matter. From § XCIX:

The beginning of the physician's secret: knowledge of the heart's movement and knowledge of the heart.

There are vessels from it to every limb. . . .

From § C:

There are 2 vessels to his testicles, it is they which give semen.

According to this conception, semen is merely stored in the testes. It is carried to them in blood vessels from the heart. This was no mere transient notion, for we find it current twenty-eight hundred years later. Needham (1934) has recently called the attention of the

biologists to a passage in Dante's *Purgatorio* (A.D. 1318), which derives the semen from the excess blood which had acquired its "formative virtue" in the heart. There are many points of interest in this passage (Canto XXV), and it is possible that Dante really believed in a form of pangenesis, although on the surface his derivation of semen from the perfect blood of the heart seems to be inconsistent with even a most liberal interpretation of the doctrine. Three hundred years later, however, Sir KENELM DIGBY (1645) stated that the circulatory blood, by coming into contact with all parts of the body, brought back to the heart all the "specific virtues" of the several parts, which were thus made available for the semen. Dante, himself, did not tell how the heart received its "informing" power from all the parts of the body and we cannot tell definitely what his ideas were on the subject.

Actual drawings of the human body in the thirteenth century after Christ could be used to illustrate the *Papyrus Ebers*. A late thirteenth-century Provençal MS. (D. II, 11, in the Basle University Library) contains two drawings, one of the male, the other of the female generative system, which show the vascular ducts through which the semen was supposedly collected from all the parts of the body. SUDHOFF, who discovered this MS., printed these illustrations in his *Geschichte der Anatomie im Mittelalter*, Leipzig, 1909, and they were copied by CHOULANT in his *History and bibliography of anatomic illustration*, Chicago, 1920. They illustrate a conception of the "seminal veins" as old as the sixteenth century before Christ.

The first actual description of pangenesis is to be found in the works of HIPPOCRATES (ca. 400 B.C.). One such passage from *Airs, waters, places* has already been quoted (p. 93). But earlier Greek thought was well prepared for the idea and the probabilities are that Hippocrates merely reflected the prevalent opinion of his time. ANAXAGORAS (498-428 B.C.) in particular came very close to the complete hypothesis. Perhaps, if his work had not been lost, he and not Hippocrates would be credited with originating pangenesis; as it is, we know of his ideas on the subject only through a chance reference to him in the *Scholion* in the work of ST. GREGORY, Archbishop of Constantinople. The passage is to be found in the Migne collection (Ser. II, Vol. 36, p. 911). It reads as follows:

But Anaxagoras having found an old belief that nothing comes from that which is nowhere, did away with creation and introduced separation in place of creation. For he nonsensically said that all things were blended one with another but were separated out as they developed. For he said that in the same semen there was contained both hair and nails and veins and arteries and nerves and bones and that they happened to be invisible, because of their smallness, but as they developed little by little they were separated out. For how could hair be produced from non-hair and flesh from non flesh?

Anaxagoras clearly thought that the semen contained material of the various parts of the body already com-

pletely formed. His contemporary, DIOGENES OF APOLLONIA believed that semen was derived immediately from the more subtle parts of the blood, perhaps ultimately from the whole body. The following quotation is from *The instructor* of ST. CLEMENT OF ALEXANDRIA (I, 6, 48):

But some suppose also that the semen of the animal is froths of the blood in essence, which in fact, because of the congenital warmth of the male being excited during coition, as it is blown forth foams out and is supplied by the veins in the insemination, for Diogenes of Apollonia believes that for this reason we get the name of *aphrodisia*.

Hippocrates himself described pangeneses in several different works. In *The sacred disease*, he repeats the statement, "As the seed comes from all parts of the body, healthy particles will come from healthy parts, and unhealthy from unhealthy." In *On generation*, sections 1 and 3, the same idea is repeated but in more detail.

1. Law governs everything. The sperm of man comes from all the humors which are in the body, and it is the most active part which separates off. Here is the proof: after coition, the evacuation of such a small quantity of semen renders us feeble. The disposal is thus: veins and nerves run from the whole body to the genital parts; rubbed, warmed, and full, a longing occurs which gives pleasure and warmth to the whole body. The humors grow warm in the body with the friction of the genitals and their movement. They dilate and are stirred by the movement, and become frothy just as all liquids become frothy when agitated. In this manner, in man, the sperm separates itself, the humor becomes frothy, the most active and most corpulent part collects in the dorsal marrow; in effect it collects there from the whole body, the brain particularly discharges into the loins, and into the marrow, which, in its turn, is supplied with efferent veins in order that the humor may both flow there, and later leave. The sperm, once it has arrived in the marrow, passes along the kidney; for that is where the channel is through the veins; and in case of ulceration of the kidneys, evacuated with the semen. From the kidneys, the semen proceeds to the thousands of parts of the testicles and to the genital member, not by the urinal tract but by another particular tract (ejaculatory ducts) which is close by.

3. I say that the sperm comes from the whole body, from the solid parts as well as from the soft parts and from all the humors which are in the body.

A contemporary of Hippocrates, DEMOCRITOS, also described pangeneses in a work which has been lost. We know of his contribution only through a short passage quoted by PLUTARCH in *De placitis philosophorum*. From Bk. V, Ch. 3:

Democritus [says] that it [semen] proceeds from all parts of the body, and chiefly from the principal parts, as the flesh and muscles.

On the other hand, ARISTOTLE utterly rejected pangeneses, after he had considered the hypothesis seriously and had argued the matter pro and con in the approved manner of his time (*Generation of animals* I, 17; I, 18). In favor of pangeneses he urged (1) the intense pleasure of coition, pleasure felt by the whole body;

(2) the alleged inheritance of mutilations; (3) the resemblance of young to their parents, part for part; and (4) the reasonableness of the supposition that, as the whole arises from some primordium (the semen), each part should have a seed peculiar to itself. The arguments against pangeneses seemed the stronger, however, and he rejected the doctrine. He held that the resemblance of children to their parents was no proof of pangeneses, for they resembled their parents in hair, nails, voice, movements, etc., which of course could produce no gemmules. He also gave many additional reasons for rejecting the doctrine, but, as they are practically meaningless, they need not be repeated here. The mere fact that the great Aristotle did not accept pangeneses, however, meant that classical and medieval opinion would be far from unanimous on the subject, although the majority was certainly in favor of the hypothesis.

In the pseudo-Aristotelian *Problems* (ca. 300 B.C.) pangeneses is tacitly implied in a number of passages in Book IV (tr. by W. S. Hett). From § 15:

Why is it that sexual intercourse is most pleasant and does it occur among living creatures because it is necessary or is there another purpose in view? Is it pleasant because the semen comes either from the whole body, as some declare, or not from the whole body but only from the area over which all the ducts of the veins extend? The pleasure then of the friction being similar in both cases, the sensation extends as it were over the whole body. Now the friction is pleasant, since it involves the emission of vaporous moisture enclosed unnaturally in the body; but the act of generation is an emission of similar matter for its natural purpose. It is pleasant both of necessity and because it has a purpose in view,—of necessity, because the way to a natural result is pleasant, if it is realized by the senses; and because of its purpose, namely, the procreation of animal life. For it is the pleasure more than anything else which incites animals to sexual intercourse.

From § 21:

Why do those who have sexual intercourse usually become languid and weaker? Is it because the semen is an excretion from the whole body, and so the composition of the body, like the harmony of a building, is disturbed by the loss of any portion of it—if, for example, all the blood of any other component part of it is removed? So important is that which the body loses in sexual intercourse, being indeed formed from a large amount of nourishment though itself small in quantity, just as a cake is made from wheaten flour.

§ 32:

This is proved by the fact that the semen is cold; for it does not become moist unless the heat warms it thoroughly. Nor does it require melting, for it is dispersed through the body like blood.

EPICURUS (341–271 B.C.) disposed of the matter very simply. As recorded in the *Lives of eminent philosophers* by DIOGENES LAERTIUS (early third century of our era) (tr. by R. D. Hicks) Bk. X, § 66:

The semen is derived from the whole of the body.

The philosopher SPHAERUS, who flourished around 220 B.C., taught pangenesis. We know this also through a reference to him by Diogenes Laertius. From Book VII, *Zeno*, § 158:

Sphaerus and his followers also maintain that semen derives its origin from the whole of the body; at all events every part of the body can be reproduced from it. That of the female is according to them sterile, being, as Sphaerus says, without tension, scanty and watery.

LUCRETIVS (99–55 B.C.), who denied the possibility of acquired characters being inherited (p. 94) described pangenesis twice in Book IV. Lines 1041–1047 (tr. by Thomas Jackson):

As soon as the seed comes forth driven from its retreats, it is withdrawn from the whole body through all of the limbs and members, gathering in the fixed place in the structure and arouses at once the genital parts alone. Those parts thus excited swell with the seed and there is a desire to emit it toward that whither the dire craving tends; and the body seeks that which has wounded the mind with love.

In the following lines he vaguely foreshadows the continuity of the germ plasma. Lines 1217–1224:

It often happens also that the children may appear like a grandfather and reproduce the looks of a great-grandfather, because the parents often conceal in their bodies many primordia mingled in many ways, which fathers hand on to fathers received from their stock; from these Venus brings forth forms with varying lot, and reproduces the countenance, the voice, the hair of their ancestors.

PLUTARCH (A.D. 46–125) is our authority for the fact that Democritus believed in pangenesis. He stated also that (*De placitis philosophorum*, Bk. V, Ch. 11), "The Stoics [say] that the whole body and soul gives the sperm; and hence arises the resemblance in the characters and figures of the children, as a painter in his copy imitates the colors which are in the picture before him." Plutarch's own views are not really stated, in fact his whole essay is little more than a listing of the many guesses that the ancient philosophers made concerning the nature of the reproductive process.

In medical literature pangenesis continued to flourish. It is definitely indorsed in *An animal sit id, quod in utero est*, a book which has generally been ascribed, though probably falsely, to GALEN (A.D. 130–200). From Ch. 2:

When a child is in the uterus, it should show the behavior of an animal, just as Hippocrates of the tribe of the Asclepiades says . . . ; for he sets up as his first definition the derivation of the animal from the whole body since he does not see how otherwise it would be able to appear complete unless he could believe that the animal is generated by the whole. He says, "The seed comes from every part of the body, the healthy from the healthy, but the diseased from the diseased." He said that from the sum of all the parts, the whole was produced: (and he was wrong only in calling the foetus an animal, so that he disparaged the judgment of those who said the opposite; namely that those things which were mutilated have not been perfected or completed). For since he was

unwilling to doubt that it was an animal, he said indeed that healthy bodies place aside a perfect seed, whole in this way, namely that they lack nothing in substance: but bodies which are impaired place aside a seed with a defect. . . . Rightly therefore, according to Hippocrates, will that animal which is in the womb he said to be fertile in that it is produced from the whole and is offered the strength of the whole. But, he not only declared that the animal is derived from the very whole, but he also showed that the primordia have the same potentialities as the whole of those from whom it has taken its roots. . . .

The early fathers of the Christian Church likewise had occasion to discuss the origin of semen. The theological problems of original sin and the second birth could often be explained more easily to the Pagans if similes from natural history were used. Consequently many works of religious propaganda contain unexpected records of the current biological beliefs. While opinion concerning the nature and the point of origin of the semen was far from unanimous, the majority of the writers seemed to favor the view that it was produced from the whole body.

ST. CLEMENT OF ALEXANDRIA, who probably wrote most of his books between A.D. 193 and 211, suggested indirectly in the *Instructor* (Bk. II, Ch. XI) that the seed was produced from the whole body, although the passage in Genesis which he quoted refers to the production of Eve from Adam's rib. He stated (tr. by Alexander Roberts):

For he says, "Now this is bone of my bones and flesh of my flesh." Therefore man is drained of seed as is shown by the body, for that which is produced [by the body] is the beginning of generation; nay, merely the bubbling out of material confounds, weakens and agitates the structure of the body.

CENSORINUS, a little known writer of the third century, cited the numerous current opinions as to the origin of semen. In *De die natali* (ca. A.D. 238) he states that Anaxagoras, Democritus, and Alcmaeon of Crotona believe that it comes from the marrow, fat, and flesh of the father. These parts do not constitute the whole body, of course, but certainly they constitute the greater portion. To the parts named we must add the nerves, for, at this time, the spinal nerve was often looked upon as the marrow of the back-bone. As we know from other sources that the first two philosophers he cited, Democritus and Anaxagoras, believed that semen comes from the whole body, we must admit a strong probability that the third philosopher, Alcmaeon, approached, if he did not endorse, the hypothesis. From Ch. 5:

And first, as to the source of the seed, it is a point on which the philosophers are not agreed. Parmenides thought that it came sometimes from the left testicle, sometimes from the right. As for Hipponyx of Metapont, or as Aristoxenus assures us, of Samos, he thinks that the semen comes from the medullary canals: which is proved, according to him, [by the fact] that, if one kills a male immediately after coition, one will see that no marrow remains to him. But this opinion is rejected by several

authors, and, among them, by Anaxagoras, Democritus, and Alcmaeon of Crotona. These reply, in effect, that after coition it is not only the marrow, but also the fat and even the flesh which drain from the male. Another question yet stops the authors, that of knowing if only the semen of the father is prolific, as Diogenes, Hippon and the Stoics wrote; or if that of the mother even, as Anaxagoras, Alcmaeon, Parmenides, Empedocles, and Epicurus thought. On this point, always Alcmaeon swears that he does not pronounce himself at all in a very positive manner, persuaded that no one can assure himself of the reality of the fact.

NEMESIUS, a fourth-century Bishop of Emesa, wrote *De natura hominis*. His conception of pangeneses foreshadows vaguely the idea which was current in the thirteenth century and which culminated in the hypothesis of Buffon (p. 141). Semen to him was the final digestion derived from the blood. The paths he describes for the collection of semen are identical with those described a thousand years later. Many later savants cited these paths as the means for deriving the semen from the whole body. From Ch. 25:

The reproductive force, too, belongs to the part which does not conform with reason. For without our will being involved we discharge semen in dreams, and the desire for copulation is natural. Even if we are unwilling, we are led on to it, although indisputably the act has been made to rest on us and depends on the rational soul. It is accomplished by instruments that serve the natural appetite, and we have been given the power of abstaining from our appetite and suppressing it. The first instruments of the disseminative faculty are the veins and arteries. In them, by a conversion of the blood, the first kind of fluid is produced that tends to the nature of semen like milk in the breasts. The humor is the sustenance of these vessels because they were originally produced from semen. The veins and arteries, then, refine the blood into a fluid approaching the nature of semen in order for it to be nourished. What is left from their nourishment becomes semen. It is first conveyed in a great circuitous path to the head and then it glides down from the head through two veins and two arteries. Hence if anyone cuts out the veins around the ears . . . of an animal, it becomes sterile and incapable of propagating. These veins and arteries turn into that tortuous wrapper resembling varicose veins which is near the scrotum, where the seminoid liquid flows into each testicle. There is one artery and there is one vein full of semen, in which the semen is thoroughly elaborated, and it passes through a winding column along the testicles when it is driven down by a blast [of air] since there is also an artery sending it. Libidinous wantonness shows that it is also conveyed by a vein. For when males have had intercourse for a long period and have used up the source of the seminal force and the genital humor, then with great effort they emit pure blood.

LACTANTIUS (A.D. 260–340) considered the question as to the origin of semen but he could come to no decision. From *The workmanship of God*, Ch. 12:

But that the right part contains the masculine seed, the left part the feminine; and altogether, in the whole body, the right part is masculine but the left feminine. Certain ones think that the seed itself comes only from the medulla, and certain ones think that the seed flows to the genital vein from the whole body.

ST. AUGUSTINE (A.D. 345–430) almost certainly believed in pangeneses, for he described the transfusion (not transmission) of the flesh of the father into that of the son by way of the semen. From *De Genesi ad litteram*, Bk. X, Ch. 1:

Orderliness now seems to demand that we discourse regarding the sin of the first man; but since the Scripture relates about the flesh of the first woman, how it was made, but is silent regarding her soul—it has made us much more intent on inquiring rather diligently as to how those men can or cannot be deceived who believe that just as the flesh is from the flesh, the soul is made from the soul of man by means of the transfusion of the seeds of both these things from the parents into the children.

ST. ISIDORE OF SEVILLE indorsed pangeneses in that he derived the semen from a “mixture of the food and the body.” His pangeneses thus was Buffonian rather than Darwinian. He wrote his *Etymologiae* sometime between A.D. 622 and 633. From Bk. XI, no. 1:

A seed is that which, having been cast off, is taken up either by the earth or by the uterus for producing either fruits or foetus. For there is a liquid, formed from a mixture of the food and the body which diffused through the veins and medulla and exuded as refuse, takes form in the kidneys, and, having been ejected through coitus and received into the uterus, is formed in the body by a certain heat of the internal organs and by the irrigating of the menstrual blood.

The gaps in our records of pangeneses following the seventh-century St. Isidore will doubtless be filled in time. The following six centuries belong to the period of Arabic intellectual ascendancy and Arabic scientific literature undoubtedly contains numerous accounts of pangeneses. We can be sure of this because the greatest authority in Islam, IBN SINA (980–1037), known to the Latins as AVICENNA, endorsed Buffonian pangeneses in his *Canon medicinae*. From Lib. III, Fen. 19, Tract 1, Cap. 3:

#### ON THE CAUSES OF SPERM

The sperm is the superfluity of the fourth digestion, which is when the food is distributed in the members by an exuding from the veins, already filled up by the third digestion, and is, from the amount of humidity, very near to coagulation, from which the radicle (solid) members are nourished, especially the veins, arteries and parts such as these. Indeed, quite a bit is found (retained) in the veins (but scattered throughout them), to which quantity the fourth digestion has already been added; and it remains in order that the veins may be nourished by it; or else it moves on to homogeneous members, which are nourished beyond the point of a necessary alteration, and because of that the sperm thrives (unto itself). And, indeed, in the opinion of Galen and the physicians, there are two semens, masculine and feminine, both of which go by the name of “sperm,” not only by a commonality of name, but by an “unison.” In each of the two semens there is the power of formation and (the power of taking on form) as well. But the masculine semen is the stronger in the power of the inception of formation, by the command

of God. And the feminine semen is very abundant in the power of taking on form. . . .

And, indeed, Hippocrates said in his "Intentions," that most of the spermatic matter comes from the brain, and that it descends by means of two veins which are located behind each ear; and, because of this, phlebotomy of both (veins) removes the power of generation and makes sterility occur. And the blood (of these veins) is (smooth and milky), the spinal marrow is adjacent to it, (so that there is no elongation from the brain), and which is similar to it for quite a long period of time, wherefore the complexity of that blood is changed from time to time and altered; indeed, (the veins) run along the spinal marrow, then to the kidneys, then to veins which run to the testes. Indeed, Galen did not know whether or not an incision of these two veins caused sterility to occur. Truly, it seems to me that it is not necessary that the sperm come from the brain only, although the fermentation of the sperm finds its source in the brain. And what Hippocrates said concerning the existence of the two veins is true: but it is necessary that the source be from every principal member of the body, and that there be from the other members a refund, even to the very origins. And, because of that, there is assimilation: and because of this, there is created a very small thing from a very small member, (until the veins are delated by puberty, and are not aroused), (following a last end and go no farther), until the digestion has been completed; and when the sperm is discharged, we have a thorough and complete mixture: and it is necessary that the discharge of the sperm precede the discharge of the blood.

The Byzantine, MICHAEL PSELLUS (1018–1078), wrote in *De omnifaria doctrina* (Ch. 83) that the "menstruals draw part of the pure blood from the whole mass" but he thought that this was merely to get the uterus in condition for conception. He stated further that

the semen of the male is possessed of the stronger, composed parts of the body, as in the bones, nerves, veins, arteries, and the like: but women are possessed of weaker parts, certainly in the blood and in each kind of bile. Or rather, all these things are due to both semen, except that the male semen excels, and the female semen has less strength.

He may really have believed in pangenesis but we cannot assume from his writings that he did. Our records show no unambiguous descriptions of pangenesis until the thirteenth century. Then, the philosophers seemed to be trying to make up for lost time, for they discussed the matter more copiously and in much greater detail than any of their predecessors. Like St. Isidore, their description of pangenesis anticipated Buffon.

## 2. THIRTEENTH CENTURY RECORDS

BARTHOLOMEW THE ENGLISHMAN (Bartholomaeus Anglicus), who wrote between 1230 and 1240, indorsed pangenesis. The following excerpt is taken from the translation of John Trevisa printed at Westminster in 1495. Bartholomew's work was translated as *All the propytees of thynges*. From Bk. VI, Ch. III:

The matere of ye chyld is matere seminalis, that is shedde by werkynge of generacon/ And comyth of all ye partyes of the fader & the moder/ fyrste this matere is shedde in ye place of conceyvyng abrode, that is by the drawynge of vertue of kynde heete/ for if the degeste blood of the fader & moder were not medlyd togyder, there myghte be noo creacon nother shapinge of a childe. For the matere of blood ye comyth of the male is hote & thycke/ And therefore for the grete thycknesse it maye not sprede itself abrode.

A chance remark of WILLIAM OF AUVERGNE in *De universo* (Ch. 25, A.D. 1231–1236) in a passage devoted to discussing the possibility of hybrids being formed and of offspring resulting from the coition of women with incubi shows that he held the prevailing view. Incubia, being spirits of course, had no semen of their own but they could, by assuming a female form, obtain it from some mundane creature and store it indefinitely. They could also discharge this second-hand semen in coition. William stated that

. . . although semen of this kind exists not only in flesh but from flesh and not unless there be a superfluity of the third digestion, as Aristotle has taught. Therefore, there is no mingling between spirits of this kind and women: I say true commingling partly of spirits since there is no transfusion of the generative semen into the vessels of begetting from a portion of the spirits.

The great encyclopedia compiled by VINCENT OF BEAUVAIS, the *Speculum naturale* (A.D. 1244–1254), contains passages which both deny and affirm pangenesis. In Bk. XXIII, Ch. 35, following Aristotle's authority the doctrine was denied, but in Bk. XXV, Ch. 80, where Avicenna was quoted, it was affirmed.

We, however, say with Avicenna that from the soul which is in the whole body there emanates to the organ of generation a generative force which flows into the semen, producing parts of the body—so that each part is suited to receiving its proper force. And with him we say that the first generative force of the vegetative soul is in the generator. In the semen is a generative force caused by that which is neither soul nor part of the soul, although it carries on activities of the soul. Accordingly, the descending of the semen from the left-over of the fourth digestion is a function of the first generative force, which is part of the soul: this as much in animals as in plants.

In Bk. XXXII, Ch. 10, Vincent quotes St. Isidore on the origin of semen (p. 123), and raises the question as to whether passion produces the semen or only accompanies its production. In the next chapter he traces the course of the sperm from the fourth digestion and describes the inheritance of gout. Finally, he expresses his own opinion that semen is derived from the whole body.

Sperm is the superfluity of the fourth digestion which is produced when food distributed throughout the body exudes through the bloodvessels at the completion of the third digestion. It is generated in the testicles just as in the principal parts of the body from the moisture carried down to them in the blood vessels, which is just like a superfluity of the fourth food in the whole body. It is blood which is more digested, finer. It is from the principal

parts of the moisture nearest the coagulation, from which hard parts also are nourished, like veins and arteries and similar parts. Sometimes it is found retained chiefly in the veins, to which the fourth digestion already proceeded; and it remained so that the veins are nourished from it, or that it reaches homogeneous members which it nourishes. On this account more change is necessary, but sperm comes from that nevertheless. Accordingly it is stirred up through the sperm in the passages coming from the *vena pulsabilis* and the *vena quieta*, two sources with a ramification of a great many windings and involutions, and thereafter it is poured by them into the spermatoc vessels, and thence by natural coitus it is sent into the womb.

The following paragraph is obviously taken from Avicenna (p. 123).

Ipcras [Hippocrates?] says that more of the sperm material is from the brain, and because it descends from two blood vessels which are behind two ears, the phlebotomy of both destroys reproduction and causes sterility to set in. Therefore their blood is milky—because they are not separated by a great interval from the brain and from those things which follow it the constitution of that blood is changed. For from the brain they arrive at the nape and continue along from there to the kidneys and then to the blood vessels which come to the testicles. It seems to me, however, that sperm need not come only from the brain, although the provocation for it comes chiefly from the brain. There must be a source for it from every principal part of the body, and an exudation from other members to those sources, and on that account there is an assimilation.

Guilhermus, "De Conchis." Sperm is man's semen composed of very pure substance which once belonged to the parts of the body. Nature requires that like be born from like. The reason why something from all the parts is contained in the sperm is that all the parts may therefrom be able to come forth. Here is another argument for this. If the father possesses some incurable infirmity in some member of his, as ordinary gout or gout of the hand, the son incurs a like infirmity in the same member. And hence nothing except what is in the germ gives the cause and origin of that infirmity.

.....

And so opinions vary about the production of sperm. For Ypcras [Hippocrates] says that it descends from the brain along the *venas juveniles*. Hence there is no formation of sperm when these are cut. Galenus, however, says that it descends from the liver. Other writers say that it descends from all the parts. Finally a solution in harmony with all is this: that it descends principally from the liver, but originally from all the members, and in very large part from the brain.

Perhaps the most detailed disquisition on pangenesis ever written is a four-thousand word chapter in the *Commentum in quatuor libros sententiarum magistri Petri Lombardi* by ST. THOMAS AQUINAS. The essay is in Dist. XXX, *Quaest.* II, Art. II, and bears the title "Utrum semen decidatur ex eo quod generatur ex alimento." No short selection from this work could do the author justice, for the essay should be viewed as a whole. St. Thomas examined carefully and skeptically the earlier theories in the light of his own thirteenth-century knowledge and weighed very logically what evidence he had. It is true that he sought to find in the semen both a physical basis for the transmission of

original sin and a biological justification for a belief in the bodily resurrection, but the greater part of the article is restrained and scientific. His ideas were almost exactly those of Buffon whom he preceded by about five hundred years. Indeed the eighteenth- and nineteenth-century naturalists would appear in a very different perspective if the thirteenth-century contributions were more available or better known.

St. Thomas indorsed the inheritance of acquired characters in his *Summa Theologica* (p. 95). In this work he also indorsed pangenesis and discussed the subject in a form somewhat briefer than his extensive treatment in the *Sententiarum*. The following excerpt is from Pt. I, *Quaest.* 119, Art. 2, "Whether the semen is produced from surplus food."

*Objection 1.* It seems that the semen is not produced from the surplus food, but from the substance of the begetter. For Damascene says (De Ficle Orth. i) that *generation is a work of nature producing, from the substance of the begetter, that which is begotten*. But that which is generated is produced from the semen. Therefore the semen is produced from the substance of the begetter.

*Obj. 2.* Further, the son is like his father in respect of that which he receives from him. But if the semen from which something is generated, is produced from the surplus food, a man would receive nothing from his grandfather and his ancestors in whom the food never existed. Therefore a man would not be more like to his grandfather or ancestors than to any other men.

*Obj. 3.* Further, the food of the generator is sometimes the flesh of cows, pigs and suchlike. If, therefore the semen were produced from surplus food, the man begotten of such semen would be more akin to the cow and the pig, than to his father or other relations.

*Obj. 4.* Further, Augustine says (Gen. ad. lit. x.) that we were in Adam *not only by seminal virtue, but also in the very substance of the body*. But this would not be, if the semen were produced from the surplus food. Therefore the semen is not produced therefrom.

*On the contrary,* The Philosopher [Aristotle] proves in many ways (De Gener. Animal i) that *the semen is surplus food*.

I answer that, This question depends in some way on what has been stated above (A. 1; Q. CXVIII., A. 1). For if human nature has a virtue for the communication of its form to alien matter not only in another, but also in its own subject, it is clear that the food which at first is dissimilar, becomes at length similar through the form communicated to it. Now it belongs to the natural order that a thing should be reduced from potentiality to act gradually: hence the things generated we observe that at first each is imperfect and is afterwards perfected. But it is clear that the common is to the proper and determinate, as imperfect is to perfect: therefore we see that in the generation of an animal, the animal is generated first, then the man or the horse. So therefore food first of all receives a certain common virtue in regard to all parts of the body, which virtue is subsequently determinate to this or that part.

Now it is not possible that the semen be a kind of solution from what is already transformed into the substance of the members. For this solution, if it does not retain the nature of the members it is taken from, it would no longer be of the nature of the begetter, and would be due to a process of corruption, and consequently it would not

have the power of transforming something else into the likeness of that nature. But if it retained the nature of the members it is taken from, then, since it is limited to a certain part of the body, it would not have the power of moving towards (the production of) the whole nature, but only the nature of that part.—Unless one were to say that the solution is taken from all the parts of the body, and that it retains the nature of each part. Thus the semen would be a small animal in act, and generation of animal from animal would be a mere division, as mud is generated from mud, and as animals which continue to live after being cut in two: which is inadmissible.

It remains to be said, therefore, that the semen is not something separated from what was before the actual whole; rather it is the whole, though potentially, having the power, derived from the soul of the begetter, to produce the whole body, as stated above (A. 1; Q. CXVIII., A. 1). Now that which is in potentiality to the whole, is that which is generated from the food, because it is transformed into the substance of the members. Therefore the semen is taken from this. In this sense the nutritive power is said to serve the generative power: because what is transformed by the nutritive power is employed as semen by the generative power. A sign of this, according to the Philosopher, is that animals of great size, which require much food, have little semen in proportion to the size of their bodies, and generate seldom, in like manner fat men, and for the same reason.

*Reply Obj. 1.* Generation is from the substance of the begetter in animals and plants inasmuch as the semen owes its virtue to the form of the begetter, and inasmuch as it is in potentiality to the substance.

*Reply Obj. 2.* The likeness of the begetter to the begotten is on account not of the matter, but of the form of the agent that generates its like. Wherefore in order for a man to be like his grandfather, there is no need that the corporeal seminal matter should have been in the grandfather; but that there be in the semen a virtue derived from the soul of the grandfather through the father. In like manner the third objection is answered. For kinship is not in relation to matter, but rather to the derivation of the forms.

*Reply Obj. 4.* These words of Augustine are not to be understood as though the immediate seminal virtue, or the corporeal substance from which this individual was formed were actually in Adam: but so that both were in Adam as in principle. For even the corporeal matter, which is supplied by the mother, and which he calls the corporeal substance, is originally derived from Adam: and likewise the active seminal power of the father, which is the immediate seminal virtue (in the production) of this man.

But Christ is said to have been in Adam according to the corporeal substance, not according to the seminal virtue. Because the matter from which His Body was formed, and which was supplied by the Virgin Mother, was derived from Adam; whereas the active virtue was not derived from Adam, because His Body was not formed by the seminal virtue of a man, but by the operation of the Holy Ghost. For such a birth was becoming to Him, WHO IS ABOVE ALL GOD FOR EVER BLESSED. Amen.

As we would expect ST. ALBERT THE GREAT had much to say concerning the origin and nature of semen. In fact his contributions to the subject, while scattered, are probably more voluminous even than those of St. Thomas. In *De animalibus* particularly he discussed the derivation of sperm from the body and used pangogenesis to explain such problems as sex-determination and the resemblance of children to their parents. In

the following passage (Bk. III, Tract. 2, Ch. 8; No. 15) he described pangogenesis in its dominant thirteenth-century form.

Hippocrates of Cos said, however, that all sperm descends from the head through two veins which he calls spermatica. They are continued behind the ears in the nape of the neck where the upper part of the neck joins the head and finally they lead to the kidneys and therefore pleasure is also felt in the kidneys. At last they come to the genitalia, and he says there is proof of this in that certain ones having been wounded in war even to the breaking off of these veins suffer sterility and can no longer produce sperm. Galen said however that he didn't know whether what Hippocrates says was true or not: but he said *à propos* of this idea that it was more probable that the sperm, which was the "superfluous" of the fourth digestion, exudes from all members of the body but especially from the head and receives by chance a mixture in the head for it is completed there more quickly, because in the head are the more noble forces of the soul. However, the "porousness" of similar members, the semen is lowered and is attracted by the testicles, just as blood is drawn by "ventosa," and in the testicle it is whitened and receives a further refining the virtue of which comes from the heart, and then it is complete for generation, just as we said in the other [cases]. There is proof that it exudes from all members of the body because it has the potentiality of forming the whole body: and we see in many animals a member lacking at birth which was deficient in the generating forces. Aristotle seems to believe that women may not have sperm and I think this is true; but this will be discussed in the following.

St. Albert stated similar conclusions in Bk. XV, Tr. 2, Ch. 2 ("whether the sperm is divided from the whole body as Empedocles and Anaxagoras said") and in Chapter 3 he describes pangogenesis and the inheritance of mutilations in his discussions of sex determination. From Ch. 11 comes the following excerpt:

It is certain therefore that the sperm is the superfluity of the final separation, which forms the conception, and becomes white due to the strength of the separation; which induces and begets life within itself, and which begets the likeness of the vessels of the sperm. And the fact that it is from the blood shows that when coition occurs with too much endeavor, it issues forth bloody: and likewise through a similar process in a woman also, menstrual blood is a superfluity of the final separation or distribution—although it is not so strongly distributed due to the white color: and therefore, it does not reach the similarity of the sperm's distribution.

Pangogenesis is also described in Bk. XVI, Tr. 1, Ch. 14; Bk. XVIII, Tr. 1, Ch. 5 and Tr. II, Ch. 4, and in these passages it is used to explain family resemblances. In the following extract from *De nutrimento* (Bk. I, Tr. 2, Ch. 2) we can observe how completely St. Albert anticipated Buffon.

Therefore as a result of these demonstrations it seems that the seed is taken from nourishment which is sufficiently expanded by the soul. That which is not sufficiently assimilated, however, is not sufficiently dispersed. And therefore it is necessary that there be a cutting off of the seed by the final digestion of nutriment before it is united to the body. This occurs, however, when the fourth digestion has been completed in itself. And therefore Aristotle

telian philosophers say that the seed is the superfluity of food (left) after the fourth digestion and taken from the whole body and particularly from the head: indeed from the whole body because it is entire in potentiality and because it can produce every member. However, it comes down more from the head than from any other single member; on account of this, namely, the fact that the soul houses itself in it not as the first impulse of the body, but as an artificer fashioning for himself a dwelling place. And because the properties which separate the animate from the inanimate, that is, movement and sense, are in the head, and therefore it comes down particularly from the head. Moreover, a proof of this is the fact that workings of the brain are greatly weakened by much coition: and a further proof is that if certain veins next to the temples, which are called spermatical, are broken, no more sperm is produced.

Moreover, the seed having been thus released from the whole body as Constantine says, it follows two special veins through which it descends to the testicles, which two veins opened through the heat caused by the friction of coition emit the seed in coition. This indeed is not probable. For, since it is necessary for the seed to be cut off from the whole body, it is necessary for these two veins to terminate at all the members. Moreover, up to now, since the start of the veins is from the heart or from the liver, it is fitting that first there be an overflowing and the seed ought to distill to the seminal vessels, which indeed does not seem probable as is shown by experiments. And therefore this is more probable that the seed diffuses through the "porousness" of the body and is drawn by the testicles just as "atrahit ventosa," and just as nutriment is carried to the members, as Aristotle said. The temperature of the body having been excited by coition; and the pores are opened so that the seed descends, which when it has descended, receives the formative virtue in the testicles, which virtue is present in these testicles, and this formative virtue is in the heat and the substance of the seed and is retained in the sperm through the very viscosity of the sperm. Moreover, this formative virtue is called "the life of the sperm": for the reason that it has the same principle as the soul.

ROGER BACON'S account of the inheritance of acquired characters has been cited. His conception of pangenesis is in complete harmony with that of St. Thomas and St. Albert. It is Buffonian and definitely anti-Darwinian. It occurs in *Communium naturalium* (A.D. 1268), Ch. 4, "de generatione hominis":

But about the procreation of man there is a special difficulty for on account of consanguinity and cognition, man wishes to believe that the semen from which the offsprings are born is not from food but from a substance of the body. That is very much in contradiction to Aristotle and Avicenna in his book *De Animalibus*, for they teach convincingly and manifestly that this is impossible because the semen is the residue of the best digested food which the body does not need for restorative purposes, for lost parts or for augmentations. Because of the fact that after the change of the food in the body there cannot be separated anything from the body or part of the body without suffering and pain, as is experienced whenever a part of flesh is separated or a nerve or bone or anything else. But a production of semen is not accompanied with suffering or with pain. In like manner whatever part of flesh it is dear to, and whatever part of bone is bone and of nerves nerve and thus about other things: consequently it has to be abandoned [the theory] that there is anything separated from the flesh or from the the bone or from the nerves;

[if so] it would be a morsel of flesh, a splinter of bone or a portion of bone, etc. but such is not semen. Furthermore if the semen were made from bone and flesh and from other material then it will be either through a division of a part from the whole, and this cannot be because of the fact that contrary theories have now been obtained or that it might be through a natural transmutation, or a conversion of some part of flesh or bone into semen.

In Fasc. III, Ch. 2, he states:

And when sufficient has been produced, according to Aristotle and Avicenna in *De Animalibus* a third quality starts to operate which may be called the reproductive quality and receives the residue of the food and transmits it to the place for reproduction and divides it [or reduces it] so that it can be made into an individual similar to its species

### 3. FOURTEENTH AND FIFTEENTH CENTURY RECORDS

So much for the thirteenth century. Doubtless many descriptions of pangenesis were written during the next hundred years, but at present we know very little about the greatly underestimated fourteenth century. Even a cursory search for such descriptions would include an examination of the *Opus ruralium commodorum* written in 1305 by PETER OF CRESCENZI, a work which remained so popular that forty-five printed editions in six different languages were issued during the succeeding three hundred years. Unfortunately many of these editions were brought up to date by very careless editors and translators and the order of the books and the arrangement of the chapters were often scrambled. Since few, if any, editions were properly indexed, collation is not easy. Probably, Peter himself had nothing to say about pangenesis. The writer was unable to find anything on the subject in the earlier editions he was able to examine (Strassburg, 1486; Vicenza, 1490; Venice, 1542, 1553, 1564), but in a seventeenth-century German edition, *New feldt und ackerbaw*, Strassburg, 1602, there is a passage which implicitly endorses pangenesis. From Bk. III, Ch. 8, p. 166:

The naturalists now state that the seed does not come from one or two parts of the body, because it should then happen that only such parts would grow from the seed as those from which the seed came, and the creatures would not be the same as those created and governed by God. One must admit this not only among human beings but also among the irrational animals, for they are born (monsters and mis-births excepted) with the measure of all the parts of their entire bodies the same as their parents, except that they are small as are all new born creatures, which have not yet grown, and it must necessarily follow that the seed must come out of the whole body, that is out of all the members of the body.

In the fifteenth century the doctors of medicine followed Hippocrates and Galen in placing the origin of the semen in the entire body. They were not particularly concerned with the careful *a priori* reasoning of the philosophers and theologians, so they rarely distinguished between the Buffonian and the Darwinian



conception of pangenesis. As far as they were concerned semen may either have been produced actively by parts of the body or formed merely out of excess material from which the parts themselves were built, after the growth of the body had ceased.

ANTONIO ZENO (POLICOLA) published *De natura humana*, Venice, 1491. In this work he discussed the origin of semen in some detail (p. 30–36) and described pangenesis as follows:

There are four factors of the sperm:—the matter-factor, the form-factor, the production-factor, and the end-factor. The matter-factor is the fluid of blood which is brought down through the veins to the testes from the whole body and from every member in the manner of an exudation, especially from the principal members (particularly from the brain—according to Hippocrates), and though it is not entirely transformed, yet it is suitable to being transformed.

MARSIGLIO FICINO did not describe pangenesis in so many words. That he accepted it, however, is obvious if we compare his account of semen with those of other physicians. Many physicians held that the semen flowed through the spinal cord (the marrow of the spine). The semen of course was not created there, but merely collected there from the brain and the brain received it from the blood which, in turn, came from the whole body. Thus semen could come from a few of the principal parts *and* from the entire body. Ficino's remarks on semen were published in *In omnia Platonis opera*, 1492, here quoted from his *Opera*, Basel, 1561. From vol. II, p. 1484:

To this organ the spirit flows in abundance from the very marrow of the spine; and from it trickles certain medullar drops, a most animated ferment of universal seed. There is a tube, made for the deflux of this fluid, which is joined at its end to the urinal duct—while according to Paul it is more superior and separate—twin tubes, as it were. Moreover the urinal duct, which goes down through the kidneys into the bladder is said to originate in some manner in the lung and I think for this reason; because the heart and the lungs are very thirsty, and since the later is spongy and as close as possible to fire, they therefore drink out very much fluid from the whole body. And so, under this disposition of nature, a fluid does not pour out through the urine, without having first overflowed from the flooded heart and lungs within.

A third example from the medical incunabula is furnished by JOHANNES PEYLIGK (PEYLICK) who published *Philosophiae naturalis compendium*, Leipzig, 1499. Peyligk denied the possibility of preformationism and described pangenesis as follows (p. 29):

The material portion is the matter of the semen which has flowed down from all the members of the parent himself, from whom are produced the spermatc members. The formative portion is the productive spirit which is formed from three principal spirits; namely, the vital, the natural and the animal: and from other special spirits which are separated in the individual members. And this receives its final form in the testes as the sperm.

GEORGE VALLA (d. 1500) presented several different theories of the origin of the semen, but did not

choose between them. From *De expetendis et fugiendis rebus opus*, Bk. XXI, Ch. 76, Venice, 1501:

Aristotle says that the seed is that which is able to form from itself and produce something of the same kind, as that from which it had been created. Pythagoras says that the fourth of the most useful blood is the seed, the excess of the food, as the blood and the medulla. Alcmaeon says it is a part of the brain. Plato says it is the discharge of the moist medulla. Epicurus says it is the tearing off of the soul and the body. Democritus says that the seed is from the whole body and from the most potent parts of the fleshy nerves which certain ones call hairy, other Greeks call them little veins consisting of threads.

It might be well to include here the ideas of LEONARDO DA VINCI (1452–1519) on pangenesis, although they have only recently been published. They are to be found in his *Notebooks* (edited and translated by E. MacCurdy, New York, 1938). Leonardo quoted Hippocrates, obviously with approbation, as follows (vol. I, p. 196):

Hippocrates says that the origin of our semen is derived from the brain and from the lungs and testicles of our forefathers where the final decoction is made: and all other members transmit their substances to this semen by sudation, because there are no apparent channels by which they could arrive at this semen.

Leonardo, unlike some of his contemporaries, did not believe that the Ethiopians were merely sunburned white men and again, unlike many of his contemporaries, he thought that the mother as well as the father contributed to the hereditary potentialities of the offspring (vol. I, p. 180):

The black races of Ethopia are not the products of the sun: for if black gets black with child in Scythia, the offspring is black: but if a black gets a white woman with child, the offspring is gray. And this shows that the seed of the mother has power in the embryo equally with that of the father.

#### 4. SIXTEENTH CENTURY RECORDS

During the sixteenth century pangenesis held almost undisputed sway. It was described so frequently in the medical literature that we cannot hope to cite all of the descriptions. The following quotations arranged in chronological order are only samples from a very large number. However, they show the status of the belief during the century.

LUDOVICUS BONACIOLUS, an Italian physician, who flourished in the beginning of the century, wrote *Enneus muliebris*, which probably was first published in 1502. In the passage to be quoted, he does not state that the semen comes from *all* the parts of the body, but he enumerates so many that there is little doubt that he at least believed in a modified pangenesis. From Ch. 3:

Obviously (inasmuch as it [the semen] would have to do with food) it starts out chiefly from that part which is the source of food (such as the liver), and especially from its vena cava (which, to be sure obtains a far greater

supply of this matter); if for any reason it [the matter] should be lacking in this [part], it is drawn from the other parts which lead from it and tardiness of emission is an indication (of this). From the heart [the matter comes] through the arteries; from the liver, through the veins; from the brain (although more copiously) through the veins and arteries; but above all from the region of the eyes, which is the most seminal of all the places of the head; you may learn this fact when through venereal union they [the eyes] are changed in exact measure and when through immoderate use of the sexular member the eyes evidently grow weak and feeble, when the strength, of the other parts are not yet failing. From all these [parts], I say, it is at length carried down to the seminal passages and to the testicles in which it receives that divine power of generation. For the vital spirit of begetting, coming down from the heart, becomes fructifying by virtue of the testes, from which it slips down in men to the tube of the penis, in women to the folds of the vulva which have been explained above.

The physicians were not the only ones to leave records of pangenesis. GREGORIUS REISCH in the *Margarita philosophica*, Freiburg im Breisgau, 1503, described it in Bk. IX, Ch. 36, *De origine rerum naturalium*:

. . . they say that the seed is a useful part of the final nourishment after the third digestion has been completed and has been preserved in the seminal tubes for preserving the species. It is derived, some assert, from the liver, others from the brain, still others from all the different limbs: these opinions are not necessarily contradictory if we know that the seed is derived principally from the liver, a large portion from the brain, and originally from all the parts.

Although FRANCISCUS MARIUS GRAPALDUS, in *De partibus aedium*, Parma, 1506 (fol. 86), quoted Hippocrates as the authority on the origin of semen, he traced it no further than to the brain from which it was discharged through the spinal cord. In the same year, however, RAPHAEL MAFFEIUS (VOLATERRANUS) indorsed pangenesis completely in his *Commentariorum urbanorum*. From p. 746, ed. of 1552:

Semen, which the Greeks call "gouem" as the author Aristotle says, is sent forth among men in a more copious proportion than among the other animals. Hence after coitus a weakness sets in. Moreover, it [the semen] comes forth from the whole body. The similarity of children who resemble their parents in even small markings of the body is proof. In woman, to be sure, as it pleases certain men to state, no semen is given forth, but in its place there is a monthly flow of blood; or if semen is given forth, it is scant (parvum) and is not necessary for conception.

Ten years later LUDOVICUS COELIUS RICHERIUS also derived the semen from the whole body in *Sicuti anti-quarum lectionum commentarios*, Venice, 1516. From Bk. XV, Ch. 23:

After that, the seed is located within the special place for forming a man, which seed has flowed down from the whole body of the man, which [view] I notice is pleasing to the most learned of the school of Plato, and this seed had dragged with it the formative force from the spirit of

man. Its potentiality is such that in almost forty-five days on the first six days following milk is produced. A generative shell having been thrown around the foetus from a very thin membrane such as in an egg, it becomes enclosed by the outer skin: this is understood by doctors, nor did Hippocrates keep silent concerning it in his book "Concerning the Nature of a Child."

In another passage he states that the "semen seems to slide through the spine from the brain" and he also quotes Hippocrates as his authority. Thus it is evident that he saw nothing contradictory in deriving semen first from the brain and ultimately from the whole body. The following passage is also interesting because of our modern interest in the genetics of baldness. Whether the inheritance of baldness is sex-limited or merely sex-influenced is still an open question. The observation reported by Richerius, however, suggests very clearly the experimental procedure which would settle the matter definitely. From Bk. XIV, Ch. 19:

Very learned men ask why in the same way eunuchs cannot become bald. But the reason seems to be deduced from this, because they possess much brain, and this matter concerns them—hence it is plain because they do not pursue sexual matter. The semen seems to slide through the spine from the brain: and Hippocrates likewise conforms to this opinion in his book, *De aere et aqua*. For he thought that sterility was induced by broken off veins which are behind the ears, because the semen's matter for the most part comes from the vein: in the same way do we also know the explanations to be such in the twenty-third book of Avicenna.

PARACELSUS stated that the semen came from all the members of the body, and he described its production in several of his many works written in the second quarter of the century. Perhaps the most complete description is in *De generatione Hominis*. Hartmann quoted a very pertinent excerpt in his *Paracelsus*, London, 1887. From p. 63 (this passage occurs in the *Opera omnia* II: 289 of Paracelsus, vol. II, p. 289):

From this nerve-aura or liquor vitae, in the process of the generation of man, the semen separates itself in a manner comparable to the separation of the foam or froth from a fermenting liquid, or as the quintessence (the fifth principle) of all things separates itself from the lower elements. This semen, however, is not the sperma or the visible seminal fluid of man, but rather a semi-material principle contained in the sperma, or the *aura seminalis*, to which the sperma serves as a vehicle. The physical sperma is a secretion of the physical organs, but the *aura seminalis* is a product (or emanation) of the "liquor vitae." It is developed by the latter in the same sense as fire is produced out of wood, in which there is actually no fire, but out of which heat and fire may proceed. This emanation or separation takes place by a kind of digestion, and by means of an interior heat, which during the time of virility may be produced in man by the proximity of woman, by his thoughts of her, or by his contact with her, in the same manner as a piece of wood exposed to the concentrated rays of the sun may be made to burn. All the organs of the human system, and all their powers and activities, contribute alike to the formation of the semen; and the essences of all are contained in the *liquor vitae*, whose quintessence is the *aura seminalis*, and these organs

and physiological activities are reproduced in the foetus out of this liquor. They are therefore germinally contained in the seminal fluid that is necessary for the reproduction of the human organism. The semen is, so to say, the essence of the human body, containing all the organs of the latter in an ideal form.

Pangeness is to be found even in the erotic literature of the sixteenth century and the pleasure of coition is explained by the assumption that the separation of semen from the whole body gives a desirable sensation. AUGUSTINUS NIPHUS published *De amore* in 1526. The following quotations are taken from the edition published at Leyden, 1641. From p. 11:

Lucretius, the Epicure, certainly asserts that on the part of the lover there is indeed an amorous desire by which the lover desires to transport himself entirely to his beloved. Indeed when the genital semen flows from the whole body by a single hurling of the body, he even believes that the whole body can surrender itself at a touch. Assuredly on the lover's [girl] part he asserts that there is an amorous desire by which she desires to take captive her lover entirely.

From p. 104:

Experiment itself indeed demonstrates the fact that lascivious action becomes especially voluptuous. But why such great delight has been conceded to this act has always been a great, and as yet unsettled, contention among natural philosophers and doctors. Some, like the Platonists, ascribe to coition such a great pleasure because the genital semen, whose passage through the channel of the virga brings on pleasure, is derived from all other parts, for if it is separated in part, the pleasure also is in part. Therefore, since it is entirely separated, as they say, the pleasure likewise must naturally be felt. But Aristotle repudiated this argument *de animalium generatione* first for the reason that if there is a reason for pleasure of this kind [it is] because the semen is cut off entirely and from individual parts; the pleasure is felt first in the part only from where it first flows, then consequently in the other parts. But experience teaches that pleasure occurs at the time when the genital semen travels through the passage and not before. But Aristotle in his book of problems assigned the cause first as the result of itch for the reason that all humidity flows from the place in which it is contained through passages unusually narrow, but not freely, rather with a certain pleasant and moderate resistance, so as to cause a certain itchiness which brings to it greater pleasure by which the humidity which flows out will be more spirituous, tickling, purer and more natural.

JACQUES DUBOIS (JACOBUS SYLVIVS) whose description of the inheritance of acquired characters has been quoted (p. 98) described pangeness in *De hominis generatione, sive foecunditatis et sterilitatis causis* (1530) as follows:

Moreover, these differences of semen in quality and quantity, depend upon the organization (or other conditions) of either the whole body or of the chief parts, especially the testes. Having first treated of this [the semen] and of the menstrual blood, we have abundantly demonstrated that the semen is derived from the individual parts, especially from the principal ones. Indeed inasmuch as the testes strain the semen and provide it with its final form, they also must needs affect it according to their own organization.

GEORGIUS PICTORIUS advocated a golden mean in sexual indulgence. As he believed that semen permeated the whole body he described the ill effects both of draining off too much and of not discharging enough in his *Dialogi*, first published in 1530. From *Dialogus* VI (p. 275, ed. of Paris, 1558):

Know, then that, as Galenus advocates, coition is an excellent means for the preservation of good health, if it is not too frequent, and if it is not neglected beyond its due time; for if either of these extremes occurs, damage is done: for if the semen, which is of the better substance of the whole body, is emitted in too frequent coition, the bases of the principal members of the body, members which are nourished by the beneficent abundance of this (as if from their own nourishment), collapse and hasten the advent either of old age or death. For the most part Hippocrates agrees with this opinion, for he says that coition is a mild form of epilepsy. Moreover, if such emission happens too rarely, and if semen is produced in the testicles beyond the time of repletion, it causes tetanus in the groins, unless pollutions should follow, it raises the testicles into a tumor, induces fevers, causes injury to the brain, stifles the natural warmth of the body, and harms the entire body: therefore, Celsus, I believe, spoke correctly when he advised that coition should not be too eagerly desired, nor should it be too greatly feared.

NICOLAS DE LAROCHE published *De morbis mulierum curandis* in 1542. He describes pangeness in the female. The female testes are of course ovaries. From Chapter I, section headed "Testes foeminarum":

For the vasa spermatica attract the matter of the female semen from all parts of the female body and then the testes receive it and after it has been received and prepared (cooked), they transmit it to the parastatae which are vessels embracing the womb which as they recede from the testicles, start to become a little wider until they enter the womb.

THOMAS VICARY, chief surgeon of St. Bartholomew's Hospital, was surgeon to Henry VIII, Edward VI, Queen Mary, and Queen Elizabeth. He published *The Anatomie of the Bodie of Man* in 1548. Pangeness is described in the ninth chapter entitled "The Anatomie of the Hanches and their Parts":

... the which seede of generation commeth from all partes of the body, both of the man and woman, with consent and wyl of all members, and is shed into the place of conceyving, where, through the vertue of Nature it is gathered together in the selles of the matrix of the mother, in whom—by the way of the working of the mans seede, and by the way of suffering of womans seede mixte together, so that eche of them worketh in other, and suffereth in other—there is ingendered Embreon.

JEROME CARDAN, whose unconsciously humorous accounts of the inheritance of acquired characters have been quoted (p. 98), also believed in pangeness. The following passage is from his *Contradicetium medicorum* (1550), Bk. II, Tract 6, Contradic. 17 (vol. VI, p. 641 in his *Opera omnia*, Lyons, 1663):

This having been seen, we ask whether the seed is cut off from the whole body? Hippocrates in the book concerning the semen says that in the beginning the veins,

arteries and nerves from the whole body extend into the private parts and therefore, the most fertile liquid which is in the whole body, comes first to the kidneys and then to the testicles until it is emitted into the vagina in coition and for this whole reason, the whole body experiences delight and in the end of the little book he says in the section concerning mutilations that the weak part which pertains to the mutilated members is spread abroad, and because of this it happens that sometimes whole children are produced and sometimes mutilated children are born from mutilated parents. Aristotle also in the fourth book of Problems asks why buttocks and eyes particularly suffer in sexual indulgence, and he answers in reply that the eyes are distended because either the seed itself or something in it is sent out from the brain and thus he thinks that the seed is taken from the brain and from other parts, since this more clearly marks out the reason why sexual indulgence delights so much. For he says that the seed either is cut from the whole body as certain of the ancients thought, or at least the veins from the whole body and all the avenues of sensations in the body extend into that part from which it comes. He firmly declares this when he shows why a man is particularly weak from intercourse, he says because the seed comes from the whole body, otherwise, it would be necessary that some parts suffer nothing at all which is a view opposed to experimental evidence. Avicenna also has these views: and it seems to me that the seed is not from the brain alone, but the source of this seed is from every principal member and it even exudes from other parts, nor is the whole seed from the brain itself although it is prepared in the brain, and although he seems to assign to Hippocrates what he thought, namely that the seed is cut off only from the brain, he did not dare to announce this. And rightly, for Hippocrates (since the authority produced above seems to be from the Greek writing of Polybius) in his book concerning Air and Water says, while he is writing concerning the people of Pontus, that the seed comes from all parts of the body, and therefore bald children arise from the bald. In the second book concerning the Generation of animals, the Philosopher says that the seed itself contains in potentiality all parts of the body and is set in motion by that force by which the whole body is enlarged. Besides the two reasonings deduced from Hippocrates we bring other, for, as is shown, the whole body of an animal is injured by castration, and this would not occur unless the testicles could not longer carry the strength into the whole body; however, there is no strength unless there is a drawing together of the seed, for the seed is blended with the nourishment of the members when it is drawn off, and it transforms and injures all the members themselves (when it is drawn off), therefore it must necessarily be derived from the whole body. Again, it is necessary that everything which is such in potentiality be from something which actually is such in fact.

MARTIN AKAKIA (d. 1551) endorsed pangenesis in a treatise on the diseases of women, *De morbis muliebribus*. He believed that a deformed foetus was the result of an incompatibility between the maternal and paternal semen. If the two streams of semen did not fuse properly, parts of the foetus would be either duplicated or in some way defective. The semen, of course, was produced from the whole body. From Bk. II, Ch. 13:

Following the authority of Cornelius Gemma, in the sixth chapter of his book "On Morphology," physicians believe that abnormal offspring are born because an incom-

plete mixture of the semen of each was brought about because of the weakness of the mother: for in the one semen there is to be found that which can form the principle parts: for the physicians are persuaded that the semen is derived from all the parts of the body, with the result that that which flows from the head is suited to forming the head. If, therefore, that which in the semen of the woman was to form a head does not mature along with that which has been put in the semen of the male to form a head, either the delivery of a two-headed foetus is necessary or the birth of a foetus with a head monstrous in some other way.

GULIELMUS PANTINUS edited and commented on an edition of *De arte medica* of Aulus Cornelius Celsus published in Basel in 1552. He endorsed pangenesis as follows (Bk. I, p. 28b):

Whence it happens that the semen is indeed generated in the whole body—apparently having been up till now, unsuitable and imperfect for generation, but appropriate for the nourishing of solid and spermatic parts. Whatever these have in excess is forced down to the "vasa seminaria" and the testes, where it is more fully elaborated and at length perfected and rendered suitable for the creation of a living being.

JACOB RUEFF (RUFFUS) used pangenesis to explain the inheritance of acquired characters (p. 99). The following excerpt from *De conceptu et generatione hominis*, Ch. I, Zurich, 1554, immediately precedes the passage which has been quoted.

Wherefore it remains to be recognized in the matter of the begetting of humans as in the case of the origin of plants, that since we observe bodies different in respect to their members being produced from one [and the same] semen, we also believe that it [the semen] arises from different parts of the body. Whence have they seen that which they expound?—they who claim that the genital semen is produced only from the brain; since this is less in agreement both with the manner of digestions and with the constitution of the body. Indeed, it is certain, that some (and not a small portion) of it is derived from the brain, but the chief portion is gathered from the most important parts of the whole body. For, if we should say that the semen is produced in only one or another part (of the body), anyone will see that this follows by correct reasoning, that only those same parts should be reproduced. And so, we can rightly say, that in addition to what originates in the brain the semen is produced from the whole body and from all the most important parts thereof; indeed, its effect instructs us as to its cause [origin], especially since in the offspring we see the distinct members perfectly completed to the exact form of the body. Also, against the opinions of others, we have on our side Hippocrates himself, easily the greatest of all physicians; who himself asserted that the seed was gathered from the whole body, and so I say that what is begotten corresponds to the constitution of the begetter—a weak man being born from weak semen and a strong man from strong seed.

The great naturalist, PIERRE BELON, also derived the semen from all parts of the body and used this notion to account for the inheritance of deformity. From *L'histoire de la nature des oyseaux*, Paris, 1555:

Just as seeds produce such plants as those from which they have been gathered, so animals starting their growth

from the seed of their sex, become at length like to those from which they have originated. The seeds are excrements of the bodies, which have the potentialities of those substances from which they have come, and which proceed from the last digestion of the body's food. . . . But the seed of the female being an excrement also, has as a property all the parts of the body, which are engendered from it—not in present action but merely in matter and potentially from the male and hence it happens that sometimes deformed animals engender deformed offspring—at one time, male and another time female.

JEAN FERNEL (1497–1558) believed in a strangely limited pangenesis. He held that the semen originated in each type of bodily tissue, but not necessarily from all tissues. Thus the semen which came from any bone could give rise to all of the bones of the foetus. He expressed this idea in *Universa medicina*, Lyons, 1593. From Bk. VII, *De hominis procreatione atque semine*:

Therefore Aristotle senses correctly that the material of the semen is not separated from the entire body. Nevertheless this material must come from the cerebrum, from the heart and from the liver; these three are the principal (organs); the most however comes from the cerebrum. There is a certain disagreement about this but whoever receives an injury there is rendered sterile. If there is a slight defect offsprings are born with infirmities and ill health. From this it is that fertility is lost when the veins and arteries which are behind the ears are separated. Thus it must be assumed that the material of semen is derived and flows from the whole, so that it necessarily flows from these principal parts. There are those who think that this material not only is derived from the principal parts but from all similar parts; not only from one particular bone or nerve but that from any bone, nerve, membrane or cartilage the material of the semen is produced. Then indeed the semen which flows from a nerve or bone in conception can form all bones and nerves and not only those particular ones (from which it came). In the same manner from the matter in so small an amount of semen all similar parts are created. This is a faculty which is located in the semen that fashions and shapes all thing. There are some who say that the material of the semen is in the end but a part of prominent food which however is not produced from the whole body, but on the contrary is producing the whole.

LEVINUS LEMNIUS, whose use of pangenesis to explain the inheritance of disease has been cited (p. 99), indorsed the principle of pangenesis in another passage in *Occulta naturae miracula*, Antwerp, 1559. From Bk. I, Ch. 9:

Wherefore there are two things especially that perfect copulation, and that help to beget Children: First, the genital humour which proceeds partly from the brain and the whole body, and partly from the Liver, the fountain of blood. Then the Spirit that comes by Arteries from the Heart, by force whereof the yard is erected, and grows stiff, and by the force whereof the seed is ejected. . . .

JULIUS CAESAR SCALIGER, whose amusing account of how the Genoese became square-heads has been cited (p. 99), was inclined to follow Hippocrates in deriving semen from the whole body but, because of Aristotle's opposition, he could not accept the belief without quali-

fications. In *De subtilitate* he discussed at some length the derivation of seed from the male and female parents and raised the question as to what portions of the offspring were formed from the maternal and paternal contributions. The following citation from his comments on *De causis plantarum Theophrasti* (1566) show how he balanced his conclusions. From p. 287:

Here is a matter about which we have already advised elsewhere, to confirm by means of the opinions of Hippocrates who thought that the semen is derived from all parts of the begetting subject. Without a doubt if the semen is cut off from certain parts, and it [the operation] is done in a skillful manner, the parts will be reproduced although semen from these parts is lacking—even mutilated humans bear perfect offspring.

AMBROISE PARÉ'S (1573) remarks on pangenesis were incorporated in his description of the inheritance of acquired characters. These have been already quoted in full (p. 99). Three years later PETRO DE PERAMATO in *De facultatibus nostrum corpus dispensantibus*, Sanlucar a Barrameda, 1576, derived semen from the blood. He did not state how it got into the blood. From p. 56a:

As a matter of fact, we have spoken—and we shall repeat below—on the manner in which the semen can be produced and divided into the formative spirit and the part which undergoes formation. At this point, however, let it suffice us to have reached the conclusion that the semen is the basic principle and foundation, active as well as passive, of the human body. . . .

From the airy, oily, fatty part of the blood is produced the semen—indeed, it was meant to be the principle of life. Life is kept up in warmth and moisture and abides therein. Since, then, the blood consists of all humors and is very heterogeneous, the semen ought to be produced from the purer and more perfect part of it. This is shown by the seminal vessels, originating from the great veins and arteries, which carry down pure blood and spirit suitable for the production of semen. Moreover, the semen itself appears rather spirituous and spumy. On that account, upon the ejaculation of semen—even though it be not a great quantity—there is quite a loss of strength and we become depressed. Since there are times when, without harmful effects, we lose copious quantities of blood from menstruation, haemorrhoids, nosebleeds, and severed blood-vessels, Avicenna went so far as to maintain that in a single coitus forty times as much blood is lost as any one of the instances mentioned above.

GIROLAMO MERCURIALE published *De morbis muliebribus* in 1582. He quotes and endorses Hippocrates on the origin of semen in the section headed "Signa sterilitatis":

If by a defect of the semen, then, there is no other means of knowing, except by a knowledge of the constitution of the entire body: because it is the opinion of Hippocrates, in the book on air, water and places, likewise in his book on generation and elsewhere that: "The Semen separates from the entire body"; and so, as the body is constituted, so is the semen; thus, by whatever symptoms an abnormality of the body shall be recognized, by those very same symptoms shall abnormality and defect of the sperm be discovered. . . .

MARCELLUS DONATUS, whose description of the inheritance of disease and mutilations has been quoted, described pangenesis as follows, from *De medica historica mirabili*, Bk. IV, Ch. 18, Mantua, 1584:

Among the Romans it was also believed that the semen fell down from the brain. From this belief they concluded that those who practiced venery too often became bald; consequently that statement was a taunt of triumph of Caesar. "In Rome, unless the wives are saved we shall have an epidemic of baldness." Thus when the head of a most wanton actor was dissected after his funeral it was claimed that only a small posterior part of brain could be found. That again appears to be confirmed by those things that have been written about Hip[pocrates] and Gal[en] *Aphor lib. 6.18*; that immature youths do not become bald. Let us add that those whose veins have been cut behind the ears become weak and feeble, which has been attested among the leaders of the Scythian people *Hip. de loc. aff.* This opinion confirms even *Avic. 20.3 tract 1.c.3*. However, it must not be denied that seed can be separated from the other parts of the body. About this *Hipp. lib. de Loc and aquis* and in *Lib. de dieta I* and *de morb. mulieris 1*. writes most plainly. This opinion is also followed by *Arist. in probl. part 4 publ. 21*, although *de gen animalium c. 18* which seems somehow either to confute the mode of separation and of production or because from this, while criticized enough it can be verified that the generative semen can proceed from all parts of the body. . . . It must be believed, therefore, that the semen is derived from all the parts of the body particularly though, from the brain, spine and the medulla [marrow]. Therefore take particularly good care of these parts that are filled with the energy of creative essence. These three, brain, liver, and heart, share alike in turbid vitality.

ALBERTINO BOTTONI held that semen was an excretion, but admitted that it had its uses. In *De moribus muliebribus* (1585) he stated that it was apt to produce structures similar to those in its place of origin. From Ch. 41:

For although the semen is an excretory fluid, it is nevertheless a useful one and in addition it is fruitful by its nature, and copiously filled with the spirit of life and when taken up in a suitable matrix, it is apt to produce [something] similar to that from which it had been derived. The menstrual blood likewise, although it is held to be the excretion of the whole mass of blood nevertheless exerts no influence on the whole body but customarily brings on a vexation in non-pregnant and non-lactating women.

MAURICE CORDE in a somewhat obscure passage in his *Commentarii in librum priorem Hippocratis Coi de mulieribus* (1585) supports pangenesis. From commentary number 6:

When this happens, it is now rightly asked whether the semen ought to be considered as derived from every part or whether it [arises] rather from a perfusion of spirit and heat. Just as the chief parts are all joined to one another by communicating vessels and all the veins, nerves and arteries are continuous down to the testes and even penetrate and permeate them; so there is a meeting of spirits of every kind especially from these sources, together with heat and there is a coming together not without a violent impulse and a spasm as of heat (?), in this manner from the remaining parts, which seize and carry with them an image of some one of them although not without other things.

ARCHANGELO PICCOLOMINI described pangenesis in *Anatomicae praelectiones . . .*, Rome, 1586. The following quotation was incorporated in a footnote in Caspar Bauhin's *Theatrum anatomicum*, Frankfurt, 1635 (p. 567):

The next matter of the semen goes forth from all the parts of the body and especially from the principal viscera: it is nothing else but food which has overflowed from the optimal nutrition of the parts; for nature prefers that there be too much nourishment rather than too little. This [nourishment] is then changed by the parts and when abandoned by assimilation (i.e.—when the process of assimilation has finished working on it) it has received the strength (power) of the parts. Wherefore, the nourishment which overflows from the nutrition and assimilation of the brain is the nearest (proxima) matter from which will be developed that portion of the fecund semen, from which the brain of the foetus itself will be produced. Now, when the nourishment overflowing in the brain cannot reach the testes because of the cutting of those veins, then they [the testes] become unfruitful. In the same manner, men will become sterile if the vein which leads from the heart or from the liver is cut; since it is especially the overflowing nourishment, or seminal material of these parts, which is the cause of the semen becoming fertile.

HEIRONYMUS MONTALTUS discussed the origin of semen in great detail in *De homine sano*, Frankfurt, 1591. In Chapter 2, "Concerning the nature of semen, etc.," he accepted pangenesis. His idea of parents weakening the bodies of their children through an excessive amount of coition is in harmony with popular beliefs which existed into the nineteenth century. From p. 6:

. . . from the nature of which the semen itself in particular comes from the whole body; for from the life-giving spirits in its midst it derives from the whole body natural faculties and all handmaids by which the semen has actually been endowed, as Galen has shown very well in his books "On the Powers of Nature," and especially does the semen derive substance from the important parts necessary to life and in particular from the heart itself: therefore, this was the result, that a perfect foetus is brought forth by mutilated parents, and parts similar to the parts of the parents are produced. Accordingly, also Aristotle on this fourth book "On the Birth of Animals" reported that "if the semen did not come from every part of the animal, the reason for the similarity of the offspring to the parents would be false. Therefore, although what is taken from the animal at that very time may be quite robust, it is not without some good reason that it happens that an exceedingly feeble offspring may be the result of coition: As Galen has noted in his first book "On Semen," where he stated all that has been said here and remarked that in the emissions of semen, especially in excessive and unremitting emission, all the parts of the whole animal are emptied of their proper nourishment and at that time are stripped not only of the very serum-filled fluid but also most particularly, of that vital spirit, which, together with the genital fluid is taken out of the arteries. Therefore Galen remarked that it is no surprise at all if quite feeble offsprings are the result of immoderate coition, since the entire body of these creatures is deprived of its purest and most robust part. In addition to what we have mentioned, take into account the matter of lust, which of itself is sufficient to destroy the vital stability; and, furthermore let it now be agreed to

that certain people are practically in the state of death as a result of too much lust and enjoyment. Moreover, in the chapter we have mentioned Galen shows us very well how this unsuitable weakness (as related to the emission of semen) reacts; for since the separate parts of the body always deliver fluid which streams to them in the way of nourishment and that they may return something very similar to themselves and change it into their own nature, and also that the separate parts may prepare food for themselves reciprocally and transmit it, and that the spermatic vessels and testicles and revolution of the vessels which are being prepared (vessels which on other occasions usually are full of semen) may be internally emptied of this fluid in excessive coition: it so happens that the testicles, constrained by the need for nourishment, then with greater violence and with more frequency deliver and thoroughly discharge from the superior ramifications of the vessels whatever seminal fluid is contained in them. Indeed when this fluid is violently released from the testicles, which have within themselves greater force, and when it is released in like manner from other upper organs, and, again, from other veins superior to a greater degree: all these immediately draw from the nearby parts, and so it goes on successively, until this reciprocal influence, diffused throughout every part of the body (from which these things must be drained), gets proper nourishment from all the parts of the body of the animal: with the result that sometimes because of excessive and unfit movement and violence (during coition) blood, not just bloody semen, may be discharged.

THOMAS COGAN, who described how diet, acting for many generations, had so altered human beings that they could no longer live on the simple fruits which had served for Adam (p. 100), thought that a moderate use of venery was necessary for health. Without venery, semen accumulated in the body, and, as he believed in Buffonian pangenesis, this excess and unused nutrition caused disorders if it accumulated beyond a certain point. He recorded his idea in *The haven of health*, London, 1596. From Ch. 242, "Of Venus":

So that none neither male nor female is cleane without it, [venery] although it burne more in some than others, according to age and complexion: although some can better bridle it and subdue it than others, according to their gift and grace. Now to enter more deeply into the nature of mankind, and to consider from whence this concupescence doth arise, you shall understand, that as every living creature doth feede, and as the meat received is altered and changed three times, that is to say, in the stomache, liver, and parts before it nourish the body, and as every concoction hath his superfluity, or excrement, as the stomache ordure, the liver brine, the veines sweate: so after the third and last concoction, which is done every part of the bodie that is nourished, there is left some part of profitable blood, not needfull to the parts, ordained by nature for procreation, which by certaine vessels or conduits serving for that purpose, is wonderfully conveyghed and caried to the genitories, where by their proper nature that which before was plaine blood, is now transformed and changed into seede.

Our sixteenth-century quotations are concluded by repeating the sage advice of WILLIAM VAUGHAN who published *Directions for health naturall and artificiall*, London, 1600. Vaughan believed in leading a natural life and warned against the dangers of an over indulgence in chastity. From Ch. IV, § 3, p. 64, ed. of 1626:

*What is the use of venery?*

This kinde of excrement is common to all living creatures, as well beasts as men. For which cause nature (like a wise mother) hath provided, that every concoction hath his excrement or superfluity, the stomacke sends out dung, the liver urine, the veins sweat: so after the third and last concoction which is done in every part of the body, that is nourished, there is left some profitable blood, reserved by nature for procreation, which blood wee call the generative seed; the moderate and timely evacuation whereof availes much for the bodies health: for by it the body is made light, and disburthened of flegme and other superfluous humors, which otherwise would waxe ranke: as we may observe in ancient Maydes and some chaste Schollers. For besides their secret flames, and unbridled affections, which dispose their minds to waywardnes and extravagant imaginations, we see them also ill-complexioned, by reason of such vaporous fumes, which descend up towards their cloudy braines. I will pass over the other unconviences, which they are subject unto, as the greene-sickness, the riding mare, the spleene, and palpitation or trembling of the heart, and their polluted dreames. The best advice which I can give them is to marry in the feare of God; chiefly, if they be sanguine-coloured, or of leane bodies, for these abound with blood.

##### 5. SEVENTEENTH CENTURY RECORDS

The dominant view of the seventeenth century was the same as that of the preceding hundred years. The physicians followed Hippocrates in deriving semen from the whole body. Likewise the philosophers and naturalists explained the inheritance of acquired characters and even heredity itself by this most useful doctrine. At this time also the problem of hereditary disease attracted the attention of numerous physicians and philosophers. The explanation which they offered differed little from that which had been current for the past two thousand years. Incidental references to pangenesis by BAUHIN (1614) and by ZARA (1615) have already been quoted.

RODERICUS À CASTRO wrote voluminously on the problems of generation in *De universa mulierum medicina*, Hamburg, 1603. Here we can cite merely his statement of the problem. From Bk. II, Ch. 1, p. 22:

Now, then, it was recorded above that there are two principles of our procreation, semen and menses; and, accordingly, the origin of a magnificent being, a weak origin delicate, certainly feeble, and even corruptible and mortal: we have, therefore, been able to pass judgment concerning these things in this book; first of all, concerning semen, whence it comes, what it is, what its nature is, and whether women emit semen; what it means to procreation, whether it is living matter or animated, whether it flows from all parts of the body, where it is produced, and where it takes on its form, what the testicles infer to its production, and whether members rising from the same semen, and impoverished, can be renewed by any means at all; and, finally, what formative faculty is contained in it, and what the condition is of good, prolific semen; and, we have explained these things in detail, but briefly and concretely.

DERMITIUS DE MEARA in his *Pathologia haereditaria generalis*, Dublin 1619, shows himself to be in the orthodox medical tradition. From Ch. I:

Now if the following factors—locality, season, wind, and age—have such great power to contaminate people through the joint participation of sky and sun: can the semen, which is the intrinsic, essential principle of many things, be properly denied the same power? Since we do admit that by a certain hereditary force the virtues and vices of the parents, which are considered diatheses of the soul rather than of the body, are communicated by the semen to the offspring, what prevents our believing that diseases—material, corporeal ailments—are communicated by parents to their children by an extremely remarkable seminal power, fertile no less in good things than in bad. Indeed, since the semen contains potentially within itself the idea, form, and characteristics of the individual parts of the body from which it issues—and in it is to be sought the particular make-up of sex, temperament, and appearance—one might well wonder, in cases of parents afflicted with any sort of disease, at the fact that the fertile power latent in the semen does not descend to the children.

BALTHASAR CÖRNERUS, like de Meara, explained the inheritance of disease by assuming that semen came from the whole body and that any bodily defect would affect the semen which that particular part of the body produced. From *De morbis haereditariis*, 24, Wittenberg, 1627:

And, indeed, it can be seen that the subject concerning the spirits, which are contained in the semen, is not a difficult one at all; for these spirits flow together from the entire body, either for the purpose of giving them sufficient value by being attracted from all parts of the body by a force placed by divine means in the testicles, and then to be united and joined in the semen; or the fact of the concurrence of the vessels in the testicles stands as another explanation. But, therefore, note that no one will very easily spoil this semen, since it passes down from all parts of the entire individual, and since it pervades everything. Hence unavoidably the formative faculty, employing the spirits with properties of the kind we have described, will form parts corresponding, of course, to the human species. There is produced an individual with certain definite endowments, qualities, and substances; for such spirits as these are made to participate and come into play. Now these formative faculties are either natural for the parents or supernatural.

There are, as they commonly say, contained in the human body three spirits,—and this dogma is fully accepted by all physicians: and these three principal parts are enumerated, on every firm basis, as the Brain, the Heart, and the Liver. Thus we may justly believe that a more outstanding and more powerful portion of semen, full of this triple spirit, flows from these three chief sources. Undoubtedly from the brain and the spinal marrow through the nerves which are found in the first and even in the twenty-first lumbar arise the vertebrae of the entire spine and with an artery transferring the matter of kindred semen, they (the vertebrae-to-be) are borne into the testicles. From the Heart (the semen flows) through spermatic arteries which are sufficiently conspicuous. Yet, from the Liver (the semen flows) through spermatic veins which no one as yet has come to know.

These three spirits, each trying to excel in their productive quantities the nature, constitution, and energy of the formative power, separate and glide into a nature such as produced them. For if the process of human generation is examined rightly, the procreative faculty, by the first seven-day period after conception, produces from the single semen three almost conceptacle-like bubbles brought about by the spirit: and these are the rudiments from which are

to be formed the Brain, the Liver, and the Heart, rudiments in which are also the arrangements and qualities of the parts from which they flow; and they are hidden until, with the advancing of time, marks, very similar to the parts of the embryo and corresponding to the same parts of the parents, become clearly imprinted.

ALONSO CARRANZA denied precisely and specifically that semen came from the whole body. It is interesting to record, however, that he was concerned with a legal rather than a medical problem. He wanted to determine the legal meaning of the phrase, *disturbatio sanguinis*. The problem arose over the marrying of pregnant widows.

Hence the phrase “*disturbatio sanguinis*” in the *Lex Liberorum* means the same as a mixture or concourse of different semina. Such is the state of affairs when a woman marries a second husband although she has an unborn child of seven or eight months conceived by the first husband. Doubtless the civil law sought to avoid this because of the honor due to the former husband, which would not remain unblemished if his posthumous offspring, a precious pledge of the parental love, were to be wetted and disturbed by the “sanguis” or “semen” of the second man.

Thus Carranza held that the blood and semen were synonymous. He recorded his idea in *Tractatus . . . de partu naturali et legitimo*, Geneva, 1629. From p. 575:

Of course, from all these factors it has become necessary to reject the view of Hippocrates at the beginning of the first book of “*De Genit.*,” as well as a bit later—namely, that the semen comes from all the parts of the body. The idea had been expressly combated by Aristotle (*De Generat. Animal*, lib. 1, cap. 17 & 18) and in modern times, Marsil. Cagnatus has done so, employing numerous arguments, (“*Varia. Resolutionum*,” lib. 1, cap. 2). Add Plato in with these, who toward the end of dialogue “*Timaeus*” speaks as follows: “That traveling of the fluid which flows down through the lungs, under the kidneys, down the bladder, is mixed with spirited matter, and is removed by an emission has been diverted by others in the fashion of a pipe into the compact marrow from the head along the neck and spine. This we called sperm, or semen, above.” These ideas are assembled in detail by Pet. Garc. in chapter 3 and 4 of his book referred to.

The encyclopedic JOHANNES BENEDICTUS SINIBALDUS published a very scholarly study of human reproduction in *Geneanthropeiae sive de hominis generatione*, Roma, 1642. He reviewed the available literature critically and reached the conclusion that the whole body contributed to the semen. From Bk. I, Tract. 3, Ch 6.:

It ought to be understood, however, that the strength of the semen comes from the whole body and all of its tiniest parts, so that this strength may suffice for the reproduction of the offspring—like a first efficient cause. The substance possesses for protection a sort of power of endurance. . . . It is likely that some of the spirit and power from little parts of the body and the whole body rush into the testes of a sudden during violent agitation and disturbance of the body. This happens in coition itself. Evidence of the fact is that strong titillation affords the whole body exquisite pleasure.



His conclusions are stated in more detail in Bk. V, Tract. 1, Ch. 13:

Meanwhile you may gather from these words that the semen is derived from the whole body, especially flowing rather plentifully from the brain through the spinal marrow. . . . But this much you should consider as certain: Either the substance of the semen is supplied freely from the whole body and chiefly from the brain, so that when the seminal paths are empty, the particles of the whole body and chiefly the brain have, by the economic law of nature to draw from their own nourishment to supply blood in producing semen. Or the vital spirit—this is more in accordance with reason—is given charge entirely over all the limbs. This is certainly most true. For the same or a like part would not be formed in the young unless the building spirit were derived from the building member of the parents. Suppose one should say that children are borne entirely from maimed parents? How is that building spirit given charge from the missing part? In such a case the spirit which comes from the heart does the furnishing—since this chief member is the originator of all vital spirits. And since it contains all the potentialities of the other parts, if some member—and consequently the formative spirit of that member—is lacking, the heart itself and the heart's spirit undergo changes and mold and form the small part failing in the parent. . . .

Finally as a corollary I shall add that it is not absurd for anyone to think that the semen may be derived from the whole body to the extent that it originates from the three chief members under whose control all the other parts are kept. The reason is this. What trickles down from the brain has the power of shaping brain, bones, marrow, ligaments, and membranes. What comes from the heart has the power of shaping the heart, of course, arteries, lungs, and other nearby organs subject to the heart. What comes from the liver can shape liver, veins, and all the fleshy members.

So also there have been other people who thought that the semen descends from the various parts not collectively but representatively—so that all the bones originate from one bone, all the nerves from one nerve, all the veins from one vein, within the semen, which is derived from one of every kind of organ. But if some one ask, from what bone, nerve, vein, artery, ought it originate? One might reasonably say, from the bone of the head, which is chief of the rest, from the prime nerve, from the vena cava, from the arteria magna. How moreover the semen is separated from the whole fluid—according to Hippocrates—we explain in the book on hereditary ailments.

SIR KENELM DIGBY, whose description of the inheritance of mutilations has been quoted (p. 102), rejected the Buffonian idea that semen was produced from excess nutrition, a view which had been accepted generally since the thirteenth century. He anticipated Darwin in assuming that a definite influence came from each of the bodily parts and collected in the semen. His idea is recorded in *Immortality of reasonable souls*, London, 1645. From Ch. 23:

To deduce this from its origine, we may remember how our Masters tell us, that when any living creature is passed the heat of its augmentation or growing; the superfluous nourishment setteth itself in some appointed place of the body to serve for the production of some other. Now it is evident that this superfluity cometh from all parts of the body, and may be said to contain in it after some sort the

perfection of whole living creature. Be it how it will, it is manifest that the living creature is made of this superfluous moysture of the parent: which, according to the opinion of some, being compounded of severall parts derived from the several limbs of the parent; those parts when they come to be fermented in convenient heat and moisture, do take their posture and situation, according to the posture and disposition of parts that the living creature had from whence they issued: and then they growing daily greater and solider, (the effects of moysture and of heat;) do at the length become such a creature as that was, from whence they had their origine.

Sir Kenelm states this view only to refute it. His arguments are not important, however, and need not be repeated here. After describing the inheritance of mutilations he proceeds to give a good Darwinian account of pangenesis.

Let him therefore remember, how we have determined that generation is made of the blood, which being dispersed into all parts of the body to irrigate every one of them; and to convey fitting spirits into them from their source or shop where they are forged; so much of it as is superabundant to the nourishing of these parts is sent back again to the heart to recover the warmth and spirits it hath lost by so long a journey. By which perpetual course of a continued circulation, it is evident that the blood in running thus through all parts of the body must needs receive some particular concoction or impression from every one of them. And by consequence, if there be any speciall virtue in one part which is not in another then the blood returning from thence must be endued with the virtue of that part. And the purest part of this blood, being extracted like a quintessence out of the whole masse, is reversed in convenient receptacles or vessles till there be use of it: and is the matter or seed, of which a new animal is to be made; in whom, will appear the effect of all the specificall virtues drawn by the blood in its iterated courses, by its circular motion, through all the severall parts of the parents body.

Whence it followeth, that if any part be wanting in the body whereof this seed is made, or be superabundant in it; whose virtue is not in the rest of the body, or whose superabundance is not allaid by the rest of the body; the virtue of that part, cannot be in the blood, or will be too strong in the blood, and by consequence, it can not be at all, or it will be too much in the seed. And the effect proceeding from the seed, that is, the young animal will come into the world savouring of that origine; unless the mothers seed, do supply or temper what the fathers was defective or superabundant in; or contrariwise the fathers do correct the errors of the mothers. . . .

. . . But to go on with our intended discourse. The seed, thus imbued with the specificall virtues of all the severall parts of the parents body, meeting in a fit receptacle the other parents seed; and being there duly concocted, becometh first a heart: which heart in this tender beginning of a new animal containeth the severall virtues of all the parts that afterwards will grow out of it, and be in the future animal; in the same manner as the heart of a complete animal containeth in it the specificke virtues of all the severall parts of its own body, but reason of the bloods continuall resorting to it in a circle from all parts of its body, and its being nourished by that juice to supply the continual consumption which the extreme heat of it must needs continually occasion in its own substance; whereby the heart becometh in a manner the compendium or abridgement of the whole animal.

PIERRE GASSENDI described pangenesi in his comments on the philosophy of Epicurus. His belief in the inheritance of mutilations has already been recorded (p. 102). The following excerpt is from *Animadversiones in decimum librum Diogenis Laertii; qui est de vita, moribus, placitisque Epicuri, etc.*, Lyons, 1649. From vol. I, p. 545:

Indeed, it can so happen that since the geminal veins and geminal arteries extend into the testicles, the confluence of the seminal parts occurs from the whole body into them and through them into the ultimate vessels. It happens, I say, not only gradually, heaping themselves together, and maturing together, and preparing matter beforehand, which in its due time can be sorted, but also (it happens) in that short time, when at the time of excretion the whole body becomes so disturbed that something which is exceedingly spiritous is stirred up in the various parts and is forced out, hastened up, and is of service at the time of inflation and propulsion. . . .

Although there are various further adjustments for this phenomenon of defluxion from all parts, I pass over certain of them, even that very convincing one of the labefaction of all parts, especially of the eyes and brain, that therefore, Pythagoras thought that semen flowed from the brain, Plato thought that it flowed from the spinal medulla, and so others held various opinions.

NATHANIEL HIGHMORE also described the inheritance of mutilation (p. 102). He gave his conception of the mechanism of heredity in his *History of generation*, London, 1651. He disagreed with Digby in most details, yet he advocated pangenesi. His conception of the formation of semen was essentially that of Buffon. He held that our food consists of a great variety of elements, because every part of the body requires a different type of element for its repair and reconstruction. He commented upon the views of Digby as follows (from p. 29):

For the material part of this seed, there is a large dispute whether it be *a toto vel a parte decisum*. I shall not stand to tell you the names of those who are Patrons of the one, and of the other; nor rehearse their arguments. If you examine them, you shall finde theirs most rational, that affirm the decision from the whole body; what we finde more particularly discours't of our forementioned author, in his 24th chapter (Kenelm Digby-Discourse of Bodies), we shall take up and a little review. Where he hath truly and fully evicted the wand'ring phancies of some, that would have this compound of severall parts, to be collected from every particle, so as passing by or through every little atome of the Parents body, in its passage; should be impregnated, and imbued with the nature of it, and so retire to the reserve where it is kept for generation. And afterwards these particles being fermented by convenient heat, do take their posture and scituation; according to the posture and dispositions of those atomes they visited in their passage, and from whom they received those imbibed natures. But this circulating our Author tells us, is impossible. I will not wrong him so much as to rank his more solid reasons with my own. Could we finde these chanel and conveyances in the Body, by which this matter should pass; yet I might doubt of the unquestionable verity of this doctrine. For what should hinder this matter circulating about the Body, from receiving qualities, and so likewise the nature of every part it passeth by; and

so every particle of this matter, should be impregnated with the natures of the whole; and every small Atome should become a living Creature, or else the Subsequent should blot out the Antecedent Character and the Impression should be only from the last Part. We may likewise as truly, as safely conclude with our Author, that it is impossible for every little part to remit some parts impregnated with the nature of that whole part from which it fell. This by some is thought to be done by that *Quasi Epilepsia in Coitu*, that kinde of convulsion or concussion of the parts, by which is shook off from them somewhat retaining the nature, and property of every part, and these being joyned make up the seed.

ALEXANDER ROSS' idea of pangenesi was clear and concise. He recorded it in *Arcana microcosmi: or the hid secrets of man's body disclosed*, London, 1651. From Bk. II, Ch. 12, § 2:

The seed is no part of the body, because the body is not more perfect by its presence, nor maimed by its loss or absence; nor is it the aliment of the body, because the body would not part with it: nor is it properly and excrement peccant in the qualitie; but it is the purer part of the blood, or quintessence of it, unuseful for the body when it is peccant in the quantity. 2. Because the blood is in every part of the body, and the seed is the quintessence of the blood; therefore the seed may be said to be derived from all parts of the body, for all parts of the body consume upon much evacuation of seed; and as it is from all parts, in respect of its material and grosser substance, so it is principally from the head, heart, and liver, in regard of its more aerial parts.

F. J. COLE (*Early theories of sexual generation*, Oxford, 1930) quoted Ross as follows:

The egge is not altogether a body inorganicall actually, seeing it hath different parts. Besides, it is organicall potentially, as containing in it all the parts and members of the chick that shall bee. So the seed of other animals contains potentially the animal that shall be, with all its members; therefore the common opinion is, that seed is drawn from all parts of the body because it contains in it all the parts.

GREGORY HORSTIUS in *Opera medica*, Norimbergae, 1660, discussed in detail the conflicting views of Hippocrates and Aristotle in regard to pangenesi. He sought to reconcile the two views as follows (Pt. I, p. 16):

In reconciliation of the controversy it must be noted that the semen consists of two substances: the spirited, or knuous, in which abides the generative power, and the earthly, or dense. Through the first substance the semen bears the warmth, the instrument of its operation, thereby forming and ordering the denser parts like material, and having performed its function, it partly goes off into the spirits innate in the parts and is partly expired. The second, denser substance of the semen is forced by the other into the spermatic parts, and around those of which only the earliest stages are dependent on the semen blood is poured to nourish and complement them.

ANTOINE LE GRAND, whose description of the inheritance of mutilations has been quoted, described pangenesi in *Institutio philosophiae secundum principia*

*D. Renati Descartes*, London, 1672. From Pt. VIII, Ch. 4, § 2:

However, in order that it might be understood by what device an Animal can be shaped from such a formless fluid so that it should have any resemblance to the element (principium) from which it was produced, it is necessary to suppose that the Semen of the Male as well as that of the Female flows down from all the parts of their bodies, so that there is no member from which something of the *seed of generation* is not separated. For just as a serous fluid is separated from the whole body through the Veins and is stored through "emulgentes" [probably—drain-ducts] in the Kidneys and the Bladder, where at a given moment an ejection occurs; so why not, since double Veins and a like number of Arteries go to the Testes—why should not the Seminal parts flow into these [Veins and Arteries] from the whole body and then from them into appointed vessels?

And this does not occur gradually and with any preparation of the "materia," but it happens in a rather short space of time, in which the whole body is so aroused to excretion, that whatever there is in the [several] parts that is very life-giving (spirituosum) is moved, squeezed forth and then hastens off.

The next year in his *Historia naturae*, London, 1673 (Pt. VIII, Art. 2, Ch. 2), he showed that the evidence used by certain philosophers to prove that the semen was produced in the brain could be given another interpretation.

Excessive effusion of *Semen* is most dangerous to the Brain and the Nerves and produces a noticeable weakness in these parts; as (may be seen in) those who indulge too much in *Venery* or befoul themselves with filthy contaminations. Hippocrates once thought, and it is even now believed by many physicians that the genital fluid flows off into vasa spermatica from the *brain*, and that when an emptying of this fluid occurs, the strength of the brain, is necessarily weakened. Indeed, since there are no special ducts from the brain which might bring the afore-said fluid down to the spermatic parts, it is reasonable to admit that this noble fluid is produced from the *Massa Sanguinaria*, some part of which is sent off to the genitalia no less than to the brain itself. As for the fact that excessive loss of genital fluid has a destructive effect upon the brain and brings about a weakness of that [organ], that arises from the fact that the *Blood* restores what is lost through the effusion of the semen that has been released, and supplies the brain with a thinner portion of itself; since the greatest supply of the animal spirits is [then] assigned to the spermatic parts. To be sure, since the Blood from its own substance cannot lavish sufficient upon the Genitals, it absorbs additional matter from the brain and demands back what has previously been assigned [to the brain] in order to recompense here.

NICOLAS VENETTE indorsed pangenesis in his discussion of animal hybridization and the production of monsters. From *De la génération de l'homme ou tableau de l'amour conjugal*, Amsterdam, 1687, page 538:

It is therefore easy to recognize the cause of monsters, without giving myself the trouble of pointing it out; because if it is true, as I have proved elsewhere that the seed is given life and that it comes from all parts of the body of the two sexes as experience shows us, it seems to me that it is no longer necessary to discover the immediate cause of the inclinations and of the form of the body of monsters.

JOANNES STEPHANUS KESTLERUS explained the ability of the semen to reproduce the whole body by an interesting simile in *Physiologia Kircheriana experimentalis*, Amsterdam, 1680. The following note is from a review in the *Journal des Scavans*, 8: 319, 1682:

He thus explains the virtue of the seed to arrange itself into all different members of the body that at first it contains them confusedly, but, that after a certain time, they are easily distinguished; it is by comparison with the rays of light which, passing through a window in a dark room, retain confusedly in the point of passage the kinds of things which one sees later as perfectly distinguishable [images], taking their natural form when this light has passed a certain distance, as one sees everything in this kind of experience.

MARCELLO MALPIGHI who, together with Nehemiah Grew, founded plant anatomy, described pangenesis in his essay on the kidneys. The passage is in his *Opera omnia*, London, 1686. From Pt. II, p. 289:

But, it is probable, moreover, that it [the semen] is formed from the retention of these particles, inasmuch as the substance proceeding either from the whole [body] or from the blood is a deflux (decidua) of tiny particles of semen; wherefore the mass of blood, wheresoever driven from the structure of the glands which are in the kidneys, is freed from the "exalted" salts and impurities (filth): the fermentation is kept up more easily, the first beginnings (rudimenta) of similar and dissimilar parts are brought down and separated in the work-shop of the testes and then when the semen is regathered it is more fecund.

JOHN RAY's description (1691) of the inheritance of acquired characters and pangenesis has been quoted (p. 104).

The discovery of spermatazoa in the last quarter of the seventeenth century was bound to complicate matters, although the resulting dispute between the ovacists and the spermacists was still in the future. Meanwhile, the question arose as to what was the really essential part of the semen. Was it a liquid infested with parasitic worms or were the "worms" themselves the fertilizing agent? PIERRE DIONIS discussed the whole matter in his *Dissertation sur la génération de l'homme*, Paris, 1698. He rejected the notion that the egg was fertilized by a spermatozoon on the grounds that it was silly of nature to produce a million sperms when only one was needed. A hundred and seventy years later, Charles Darwin (*op. cit.*) also rejected this notion, and held that the whole semen was the fertilizing substance and that the foetus resembled its father in proportion to the amount of semen ejaculated in coition. Dionis, like Darwin, accepted pangenesis. From p. 342, ed. of 1715:

The third opinion which tells us that the seed is a composition of several similar parts filtered and separated from the blood by the testicle is the most likely, because it is founded on the proper constitution of the part, and on a certain principle which is the circulation of humors, by which we learn that the spermatic arteries carry to the testicle blood which the veins bring back to the heart to be distributed to the rest of the mass; that the seed which is

found in the blood of these arteries is sifted and separated in the testicle when it passes through, and that from there it is conducted by the deferent vessels to the seminal vessels to serve it in need. . . .

The humidity of infancy being consumed by the heat which has more force, there occurs in the blood more corpuscles fitted to nourish the parts and repair the losses which they suffer, than is needed for this use; so that a very large number of these particles finding no place to put themselves, are obliged to return with the blood: They come back from the head particles proper to recompose all the different parts of which it is made, and so of the others; All these particles mixed with the blood thereof are separated by means of the testicles, across which they are sifted and in reassembling they form a humor which is the sensible and corporal part of the seed; he adds that producing thus more spirits than it needs to repair the loss which it makes every day, it detaches a certain quantity which is carried with impetuosity to the testicle by means of the nerves, and which mixing with the humor forms a fertile and living seed, which they say has the virtue of producing a man; in that the particles which are detached from all parts of the head, for example, have the dispositions and the movements to join themselves together, in the manner that each finds itself again arranged between the others as it was in composing this organ, there results therefrom a head altogether like it, although incomparably smaller, and from the union of the other organs formed by the same laws, there is made an infant whose members are seen in the same proportion as those of its father, which is better explained in what follows.

Later, in *Traité général des accouchemens*, Paris, 1718, Dionis states (p. 57):

Semen is a white, foaming, and animated liquid, separated from the blood by the testicles and absolutely necessary for generation. Those who have believed that it was the material cause of the child, regarded it as an assembly of a number of small particles detached from all parts of the body from which it was extracted, which separated themselves from the mass of blood when passing through the testicles, and which by the arrangement of all these particles in the matrix, each of which has a natural outline of the parts from which they have been detached, they were formed into a child.

#### 6. EIGHTEENTH CENTURY RECORDS

The eighteenth century saw numerous debates on the nature of semen. The discovery of both the mammalian egg and spermatozoa was bound to increase the number of explanations as to how reproduction was effected: Preformationism, soon to become an important issue, offered the first real competition to pangenesis in explaining how so complicated a being as a man could arise from the germinal fluids. The microscope revealed the fact that semen was not structureless and soon the acknowledged existence of spermatozoa gave rise to a school of thought which held that each spermatozoon contained within itself an embryo, which was capable of developing into a complete human being, when it was introduced into the proper nutritional environment. Opponents of this view believed that the embryo existed in the egg which needed only the stimu-

lus of the male semen to begin its growth and development. Thus, the material contribution of the female to the offspring was no longer held to be merely the liquid menstrual discharge but a complicated solid structure. We would expect that, in these circumstances, pangenesis would be superseded or at least eclipsed. Actually it still persisted and remained in good standing. Even Bonnet, himself, the leading exponent of preformationism, accepted a limited form of pangenesis and stated that the embryo could receive certain "animal spirits" from the nerves of the mother. Pangenesis was too ancient and honorable an hypothesis to be lightly abandoned. Throughout the entire eighteenth century many of the leading biologists continued to rely upon it when they had occasion to describe the origin of semen. GEORGIUS VOLCMARUS HARTMANN in *De generatione*, Erfurt, 1716, mentioned the effects of coition upon the "parts of the whole body." The facts he mentioned had been cited frequently as evidence of pangenesis. From Sect. V, p. 6:

Yet there concurs particularly an agreeable agitation of mind and body, in each mate, on account of which they not only rush into each other's embraces but there comes about a union and mingling of hearts, as it were. Besides, the parts of the whole body grow so stiff and are affected with such a spasm, so to speak, that nature seems to be aiming for this act with all her strength—as is sufficiently confirmed by the subsequent debilitation and loss of strength.

Like Hartmann, JOANNES DE GORTER recorded in detail the immediate effects of coition upon the human body, and, again like Hartmann, implied that the semen came from the whole body but did not state explicitly that it did so. From *De perspiratione insensibili*, Ch. 17, § 3, Padua, 1725:

In the testes the semen is separated from the arterial blood by a wonderful device. From an examination of the origin alone of the spermatic arteries I think that I am supplied with a sufficient reason for believing that by too great a discharge of semen the body can only be weakened. But a small quantity of it seems to be able to accomplish all this. Therefore the ancients claimed that the semen is derived from all the parts of the body. There are those who believe that this fluid is produced from the nerves. No one, as far as I know, has thus far, by a true explanation based on the mode of semen-secretion, shown that such efficacy lurks in it as is actually contained therein. But all proclaim its efficacy apart from any mechanical explanation because of its procreation of the parts of the body. . . . It seems, then, to be a liquid of utmost perfection, like spirits, for the production of which the bodily process has expended the greatest labor; when it is perfected and retained the body is thereby invigorated, but when it is discharged the body is weakened. . . . At a fixed age in men a good deal of activity goes on in the perfection of semen. Hence a moderate amount of sexual intercourse does not weaken them as women are not weakened by a moderate flux of the menses, but quite frequent intercourse or a sickly efflux of semen in gonorrhoea, as a flowing of the menses, is utterly weakening. Or if it is practiced by old men when the debilitated body no longer produces more good humor than it requires for its own preservation, it drains their strength.

TOBIAS WIRTH's record of inherited mutilations has been quoted (p. 105). In the same dissertation, *De morbis hæreditariis*, Copenhagen, 1734, he quotes and indorses Hippocrates' statement of pangenesis. From § 6:

For if, he says, there is begotten a pituitous person from a pituitous parent, a bilious one from a bilious parent, a languishing from a languishing one and a splenetic from a splenetic parent: since its father and mother have been seized with this disease, what prevents any of the descendants and grandchildren from also being seized with it? For the genital semen proceeds from all parts of the body, and healthy semen from healthy parts, the diseased from diseased parts. The same author, of such a great name in his book on air, waters, and places, when he speaks of the semen, says it happens that from bald people bald children are born, from cat-eyed people cat-eyed children are born, but that often a deformed person does not beget a deformed child.

From § 8:

. . . it seems that irregular arrangement should doubtless have been constituted in the temper and weakness in the brain of him who is finally seized with apoplexy, before he be seized by it, and just like other hereditary diseases, it (apoplexy) can be derived and communicated along with the offspring semen.

P. L. M. DE MAUPERTUIS described the inheritance of acquired character in *Vénus physique* (1745) (here quoted on p. 106), and implied that the whole body contributed to the function of the semen. In *Système de la nature* (1751) he definitely rejected preformationism in favor of pangenesis. He cited the instance of a German family whose members had six fingers to a hand. As this character could be transmitted by both male and female lines, he held that neither the ovacists nor the spermacists could be right. From *Oeuvres* II: 158, Lyons, 1756:

### XXXIII

The elements adapted to form the foetus float in the seeds of the father and mother animals: each extract of the part, similar to that which it is to form, maintains a kind of souvenir of its original condition; and it will tend to take it back again whenever it is able to form the same part in the foetus.

### XXXIV

Hence, in ordinary order, the conservation of the species and the resemblance to the parents.

### XXXV

If some elements are lacking in the seeds where they are not able to unite, there are born monsters in whom some part is lacking.

### XXXVI

If the elements occur in too great a quantity or if after their visual union, some part remains uncombined it may unite itself to some part and there is born a monster with superfluous parts.

### XXXVII

Certain monstrosities, perhaps by excess, perhaps by defect, perpetuate themselves ordinarily enough from one generation to another, or even through several generations. One knows of a family in Berlin where commonly the children were born with six fingers, which is transmitted as much by the father as by the mother. This phenomenon of which one will find several examples if one hunts them, is inexplicable in either one or the other of the two systems on generation now universally accepted; or rather it reverses absolutely both of these systems, the one which supposes the child formed entirely within the father, and the one which supposes the child formed entirely in the egg of the mother before the copulation of the two sexes; because if either one or the other of the systems is true, if we shall have observed numbers of generations of six-fingered individuals, each generation contained in the preceding, the monstrosity would have to be heritable only through the father (according to the first system) or only through the mother (according to the second system). In our case, there is not any difficulty: the first monstrosity having been the accidental effect of some of the causes described in the preceding paragraph, the habit from the situation of the parts in the first individual, makes them replace themselves in the same manner in the second, in the third, etc., as long as that habit is not destroyed by something else more powerful, maybe on the part of the father, or on the part of the mother, or by something accidental.

One of the most versatile of the scientists who discussed pangenesis was RENÉ ANTOINE DE RÉAUMUR. Réaumur invented a thermometer and an incubator and wrote an excellent history of insects. He did not specifically indorse pangenesis but he did discuss it in such detail that he showed that a competing hypothesis, the simple mechanistic explanation offered by Descartes, was inadequate. Réaumur's description appeared in *Art de faire éclore . . . les oiseaux domestiques . . .*, Paris, 1749. From vol. II, p. 326:

Let us suppose that the prolific liquors as simple as those which serve to restore the losses which occur in us daily, and give play to our imagination, as far as we are permitted. To render these liquors proper to accomplish a similar work, suppose that they contain all the material necessary for the construction of the little animated machine, which is going to be formed into a big one, and from which it differs only in size: let us try to think with several Savants that the prolific liquors, be they male or female, are composed of parts similar to those which form all the organs, be it one or the other, that is to say, that in these liquors are found parts similar to those which compose the heart, the stomach, the intestines, the head, the ears, the tongue, the nose, and, finally, that there are particles similar to those which compose each bone, muscle, vessel, valve, and even each fibre; let us suppose, in sum, that each part of the big machine has furnished the material to make something which resembles it in miniature; let us suppose that into a fleshy cavity, which makes the ovary, if you wish, have been carried the extracts, so to speak, of all the different organs; let us not make it too difficult as to the manner in which these extracts might have been made, nor mention the manner in which the particles might be conserved healthy and pure through the long and tortuous road by which they were conducted, and so remain fit to produce there the proper structure. Let us agree that they have arrived somewhere in the ovary, but we are not

able to discriminate if they are there all pell-mell, if the material proper for the formation of the eyes finds itself mixed with those which must serve to construct the stomach, if those of the heart mixed with those of the ear or with those of the head, if there would be there more irregular mixtures than we can imagine. What is the agent which distangles this chaos, assorts the parts which must be together, forms the organs, and unites the different organs to those to which they must join, and finishes at last this seed, which is so small that the best microscope cannot render it clear enough to our eyes? Is it anything less than admirable? We have said, it is not to be expected that the single action of one sweat heat can do such a work, a work incomparably more complicated than a repeater watch. . . .

. . . it has been thought that for this it need only be supposed that the similar parts of the same species have the property of reciprocal attraction, and there are different laws of attraction for the similar parts of different species; by the power of these laws, the parts proper to make a heart, all those which are to make a stomach, a head, &c. seek those, which are of their own kind, bring themselves together and are united: thus the chaos, distangles itself, the unnumbered masses composed of the most analogous parts unite. We are however still very far from seeing anything which resembles any of these organizations which must concur to form our great work. . . .

With GEORGES LOUIS LECLERC DE BUFFON we come to the most famous exponent of pangenesis next to Darwin. Darwin himself acknowledged the likeness of Buffon's hypothesis to his own (p. 107). However, Buffon and Darwin developed their ideas along different lines and the details of the process of semen formation, which they imagined, were very different. It was Buffon's pangenesis which was generally accepted although Darwin's had a number of adherents. It was also Buffon's conception which was so completely anticipated by the thirteenth-century philosophers. Buffon recorded his hypothesis in his *Histoire naturelle* whose publication began in 1749. The following quotation is taken from the English edition of 1791. From Ch. IV:

The generation of man will serve us for an example. I take him in his infancy, and I conceive that the expansion and growth of the different parts of the body being made by the intimate penetration of organic molecules analogous to each of its parts, all these organic molecules are absorbed in his earliest years, and serve only for the expansion and the augmentation of his various members, consequently there is little or no superfluity until the expansion is entirely completed; and this is the reason why children are incapable of propagation; but when the body has attained the greatest part of its growth, it begins to have no longer need of so great a quantity of organic particles, and the superfluity, therefore, is sent back from each part of the body into the destined reservoirs for its reception. These reservoirs are the testicles and seminal vessels, and it is at this period that the expansion of the body is nearly completed, when the commencement of puberty is dated, and every circumstance indicates the superabundance of nutriment; the voice alters and takes a deeper tone; the beard begins to appear, and the other parts of the body are covered with hair; those parts which are appointed for generation take a quick growth; the seminal liquor fills the prepared reservoirs, and when the plentitude is too great, even without provocation, and during the time of sleep, it emits from

the body. In the female this superabundance is more strongly marked, it discovers itself by periodical evacuation, which begin and end with the faculty of propagating, by the quick growth of the breasts, and by attraction in the sexual parts, as shall be explained.

I think, therefore, that the organic molecules, sent from every part of the body into the testicles and the seminal vessels of the male, and into the ovarium of the female, from there the seminal liquor, which is, as has been observed, in both sexes, a kind of extract of every part of the body. These organic molecules, instead of uniting and forming an individual, like the one in which they are contained, commonly unite when the seminal liquors of the two sexes are mixed; and when there are more organic molecules of the male than of the female, in such a mixture the produce will be a male; and on the contrary, when there is more of the female than a female will be the result. . . .

I conceive, that in the aliments we take there is a great quantity of organic molecules, which needs no serious proof, since we live on animals and vegetables, which are organized substances. In the stomach and intestines a separation is made of the gross parts, which are thrown off by the excretories. The chyle, which is the purest part of the aliment, enters into the lacteal vessels, and from thence is transported into every part of the body. By the motion of the circulation it purifies itself from all inorganic molecules, which are thrown off by secretion and transpiration; but the organic particles remain, because they are analogous to the blood, and that from thence there is a power of affinity which retains them afterwards; for as the whole mass of blood passes many times through the body, I apprehend, that in this continual circulation every particular part of the body attracts parts most analogous to it, without interrupting the course of the others. In this manner every part is expanded and nourished, not, as it is commonly said, by a simple addition of the parts, and a superficial increase, but by an intimate penetration of substance, produced by a power which acts on every point of the mass; and when the parts of the body are at a certain growth, they are almost filled with these analogous particles, as their substance is become more solid. I conceive that they then lose the faculty of attracting or receiving those particles, but as the circulation will continue to carry them to every part of the body, which not being any longer able to admit them as before, must necessarily be deposited in some particular part, as in the testicles or seminal vessels. This fluid extract of the male, when mixed with that of the female, the similar particles, possessing a penetrating force, unite and form a small organized body like one of the two sexes, and no more than expansion is wanting to render it a similar individual, which it afterwards receives in the womb of the female.

JOHN TURBERVILLE NEEDHAM was greatly impressed with Buffon's conception of organical particles. In an article, "A summary of some late observations upon the generation, composition and decomposition of animal and vegetable substances," published in the *Philosophical Transactions* of The Royal Society, London, 45: 614-666, 1748, he revived Buffon's work in detail. He even added to the hypothesis by describing how all parts of the body contained "strainers" which could separate out from the food the particular organic particle needed for their growth and repair. At maturity these particles, no longer needed for growth, accumulated to form semen. He summarized his conclusions as follows (p. 663):

I shall conclude therefore with summing up my System in a few words: I suppose all Semen of any kind to be an exalted Portion of animal or vegetable Matter, secreted from the Aliment of every generating Subject, when it is adult, and no further Demand is made for its Increase and Growth; this I suppose to be endued with a proportionable vegetative Force, to be various in Various Circumstances, and heterogeneous in different Subjects; but to be uniform in its Productions, when it falls into a proper Matrix, where it finds Matter to assimilate, of a Quality and in a Quantity sufficient to form that Specific Being, whilst in other Circumstances, it will, if it extravasates, by the same vegetating Force, yield all the several *Phaemonema* I have above taken notice of.

ALBRECHT VON HALLER in his *Elementa Physiologiae corporis humani*, Lausanne, 1766–1778, held that each portion of the body came from its appropriate germ but assumed that each type of germ was not localized in any one part of the body, for he explained regeneration as follows, “The head contains germs of the tail and the tail germs of the head so that when one is cut off, the other furnishes a supply of germs and these consequently receiving more nutriment are developed.” He stated the pangenesis hypothesis but did not accept it as stated, because no semen had been found in females. From *First lines of physiology*, Troy, 1803 (*Primae lineae physiologiae*, Gottingen, 1751):

881. And, in the first place it is a difficult question, from whence do the rudiments of the new animal proceed? Are they derived from both parents, and mixed into one animal by a conjunction of seminal matter coming from the whole body; as indeed there is a resemblance of the foetus to both parents in animals, but especially in plants, as confirmed by numerous experiments, and as the diseases of parents are propagated to their children?

He held that semen was produced by food particles, as evinced by the following:

824. That the semen is produced from the lymph of the blood, and that the chyle is added to the lymph appears probable from the disposition to venery quickly super-vening after eating and being lessened by fasting.

Von Haller emphasized the effect of the semen on the body rather than that of the body on the semen.

827. But a considerable part of the semen, and that the most volatile and oduous, is absorbed into the blood, and by its addition to it produced wonderful changes, impregnating the whole animal with its smell, causing the beard and the hair upon the pubes, and horns to grow, and changing the voice and disposition. For these do not happen in consequence of the age of the animal, but of the semen, and never occur in eunuchs.

GUILLAUME REY was one of the eighteenth-century physicians who sought to explain hereditary disease by assuming that the semen being produced in the whole body would naturally be defective if any part of the body was ailing. He obviously thought that the humors of the body, rather than the solids, were the source of illness. His work is entitled *Discours sur la transmission des maladies héréditaires*, Paris, 1752. From p. 8:

I say therefore in the first place that the fluids, of which it is a question, are each impregnated, that is the masculine of all the different humors of the father, and the feminine of all those of the mother.

These fluids derive from the mass of the blood, and collect because of all that this common source contains. But one does not doubt that this general force contains in one way or the other, all the different humors of the body, as much the excrements which are rejected therefrom, as the useful or beneficial parts which are used in part to serve diverse needs of the individual or of the species.

Moreover, all the body, especially the liquids, exhale more or less of their substance. Thus the diverse humors separated and perfected in their reservoirs, push therefrom several of their particles, which add to the mass of the blood without counting that some turn up again there by a sort of re-pumping. . . .

Three reasons together, well confirmed by observation, demonstrate that the mass of the blood participates of all the liquids, and that consequently the two masculine and feminine fluids, which roll forth, are impregnated with all the particular humors of the father and the mother. . . . Since therefore the feminine fluid, even as the masculine, transmits to it some diseases, as much general as local, it remains indubitable by these same effects that the two fluids in question are each impregnated with the different humors of their sources, which imprint on the embryo their particular constitutions.

CHARLES DENYS DE LAUNAY's description of the production of semen showed that he did not lack imagination and was not inhibited by his lack of data. He rejected the notion that the testes strained the semen out of the blood directly, on the grounds that the finer, more subtile blood, rich in animal spirits, did not fall to the lower regions of the body but arose to the brain. It was in the brain capillaries that the semen was first separated from the blood, and from the brain the semen descended to the testes by way of the nerves. In the testes the semen was thickened and ripened. From *Nouveau système sur la génération de l'homme*, Ch. III, p. 42, Paris, 1754:

As there are millions of these fibrous canals in the brain, what occurs there is distributed in all parts by the communication which these same fibres have with all the other fibres of the entire body.

Thus purified, it is distributed in the testicle by means of the nerves.

The nerves which are in the testicle subdivide themselves into other more minute branches, which from there to as many subdivisions of the seminary canals and lymphatic canals.

The animal spirits arrive in the space or confluence of these three canals of the testicle, which is called the seminal basin or lake, there these cause a separation of its parts for the formation of the semen, as they do in the brain for animal spirits. So that the most oleaginous, the most subtile, the lightest of these spirits take their way by the seminary canal, while the remainder of these animal spirits, less pure and thicker, take their way through the lymphatic canal.

The part of these spirits which enter the seminary conduits roll along there and collect to form a larger volume of liquid; so that the different branches of these canals reunite.

The more this liquid approaches the seminal vesicles the more it draws together and thickens, which makes one

presume that these spirits begin to characterize themselves as semen, in all the length of these canals, by a sort of baking that they receive from the heat of the arterial blood. And arriving in the seminal vessicles, as in a resting place, they succeed in perfecting themselves there, and taking on there the arrangements to mold a miniature Animal with all its parts; just as the seed of a plant contains the character and abridged form of another plant, by the arrangement that the juices of the earth have taken there after their entrance into the plant.

DENIS DIDEROT seems to have assigned a sort of figurative memory to the various particles which make up the semen. As a consequence, congenital variations would be due then either to a forgetting or to a confusion of ideas. This notion was recorded in *De l'interprétation de la nature* (1754), here quoted from *Oeuvres complètes de Denis Diderot* I (1): 447, Paris, 1818:

The seminal element, withdrawn from a part of the body similar to that which it must form in the animal, feeling and thinking, would have some recollection of its first situation; thus the conservation of species and the resemblance to the parents. It may happen that the seminal fluid is overrich in or lacks certain elements; that these elements cannot unite themselves by reason of forgetting; or that from the over-numerous elements bizzare unions occur; thus the impossibility of generation or all the monstrous generations possible.

Certain elements would have of necessity attained a prodigious facility of constantly uniting themselves in the same way; thus, if they are different, a formation of microscopic animals varied to infinity; thus, if they are alike, the polypus, which one can compare to a cluster of infinitely small bees, which having but the living memory of a single situation, gang together and live ganged together in accordance with the situation which seems to them most familiar.

When the impression of a present situation balances or extends the memory of a past situation, so that there would be an indifference to all situations, there would be sterility: thus the sterility of mules.

What would prevent the elementary parts, intelligent and sensitive from wandering completely off from the order which constitutes the species? thus the infinite species of animals from a first animal; an infinite number of beings emanating from a first being; a single act in nature.

CHARLES BONNET, who denied the heritability of mutilations, believed strangely enough in a sort of spiritual pangenesis in spite of his well known preformationism. He advanced the theory of *emboîtement*, i.e., that the germs which were to form the next generation contained in themselves germs which were to form the third generation and so on to the end of the world. These germs were not, so to say, wrapped in cotton-wool, but could be reached supposedly by the "animal spirit" of the parent. This animal spirit has a certain remote resemblance to the gemmules of Charles Darwin. Bonnet's idea was recorded in *Mémoire sur les germes* (1773) here quoted from his *Oeuvres d'histoire naturelle* V: 7, 1781:

Thus I conceive that the animal spirit is carried by the nerves of the mother into her ovaries and that it is at first distributed to the most developed germs. I shall call these

germs, the germs of the first generation or of the "first order." The animal spirit, carried in a germ of the "first order," is there fashioned again exceedingly small by the secreting organs of that organized corpuscule. The portion of the animal spirit that these organs have prepared is carried by the nerves of the germ to its ovaries and is introduced into the most developed germs or into those that I shall name the "second order." These germs extract again from the animal spirit the more subtle particles which pass to the germs of the "third order" and thus the spirit passes successively into all the germs of the series, from the germ which contributes to the actual generation, up to that one which will be said to be fertile only at the end of the World.

In vol. III, p. 65, a rather queer idea is expressed:

CXII. The surplus of what is necessary to produce this effect, is returned to all parts of the body, in a common reservoir where the liquids form. The organs of generation are this reservoir. CXIV. The seminal liquid contains all the molecules analogous to the animal or plant body, and when they find a suitable matrix they produce a little one. It is entirely like an internal link of which the molecules are a part.

When they find a suitable matrix, they produce there organized Beings, which are moving and vegetating bodies seen in the seminal liquids of these animals and in the animal or plant infusions.

In a work earlier than the one here quoted, Bonnet described how the pre-existing germs secured their nutrition and in this account he approached very closely to Buffonian pangenesis. The nutritive particles supposedly not only fed the germs but they actually modified them. This could be seen in hybrids who resembled their fathers although the pre-formed germ was purely maternal in origin. From *Contemplation de la nature*, Amsterdam, 1764 (English ed. 1766; vol. I, p. 146):

But these relations of the prolific liquor with respect to the male that furnishes it, must necessarily depend on the organs that prepare it. We know their admirable composition. It cannot be admitted, that this liquor, after having been moulded in the body of the male, is sent from all parts of him to the organs of generation, as to a common repository, there to represent the whole in miniature. It cannot arrive at this repository except by the channels of circulation. Therefore it must enter into the mass of blood; must have organs to separate it again from it, and these organs must also be those of generation.

There are then in these organs vessels that separate the molecules relative to different parts of the great whole. These molecules are carried to the corresponding parts of the germ, since these parts are modified by the action of the prolific liquor. Therefore it incorporates itself with the germ, and is the first aliment of it, as I said above.

The different systems of vessels which prepare this liquor, represent, as I may say, in miniature, different parts of the great animal. They are species of models in which different molecules are to be formed, or rather they are kinds of filters, strainers, or wire-drawers, appropriated to molecules variously proportioned and formed.

The organs of generation in the ass have then a relation to his ears and larynx; for they prepare a liquor which modifies the ears and larynx of the little horse inclosed in the egg.



If all be preformed, if nothing is engendered, neither can the long ears and drum of the mule be engendered. The prolific liquor creates nothing, but it may change what already exists. It does not engender the chick, which existed before fecundation.

At the close of the century ERASMUS DARWIN expressly denied pangenesis as it had been described by Buffon, this in spite of the fact that it furnished him a ready vehicle for the inheritance of acquired characters, a belief to which he firmly held (p. 115). He stated his views in *Zoonomia; or the laws of organic life*. From p. 557, ed. of 1800:

Lastly, Mr. Buffon has with great ingenuity imagined the existence of certain organic particles, which are supposed to be partly alive, and partly mechanic springs. The latter of these were discovered by Mr. Needham in the milt or male organ of a species of cuttle fish, called calmar; the former, or living animalcula, are found in both male and female secretions, in the infusions of seeds, as of pepper, in the jelly of roasted veal, and in all other animal and vegetable substances. These organic particles he supposes to exist in the spermatic fluids of both sexes, and that they are derived thither from every part of the body, and must therefore resemble, as he supposes, the parts from whence they are derived. These organic particles he believes to be in constant activity, till they become mixed in the womb, and then they instantly join and produce an embryo or fetus similar to the two parents. Many objections might be adduced to this fanciful theory; I shall only mention two. First, that it is analogous to no know animal laws. And secondly, that as these fluids, replete with organic particles derived both from the male and female organs, are supposed to be similar; there is no reason why the mother should not produce a female embryo without the assistance of the male, and realize the *lucina sine concubitu*.

Actually Erasmus Darwin's conception of the nutrient particle was not very different from Buffon's, for he described (p. 563) how the mother could influence the unborn offspring, as follows:

The form, solidity, and colour, of the particles of nutriment laid up for the reception of the first living filament, as well as their peculiar kind of stimulus, may contribute to produce a difference in the form, solidity, and colour of the fetus, so as to resemble the mother, as it advances in life. This also may especially happen during the first state of the existence of the embryo, before it has acquired organs, which can change these first nutritive particles, as explained in No. 5. 2. of this section. And as these nutritive particles are supposed to be similar to those, which are formed for her own nutrition, it follows that the fetus should so far resemble the mother.

#### 7. NINETEENTH CENTURY RECORDS TO THE TIME OF CHARLES DARWIN

The records which have been quoted show that the "provisional hypothesis of pangenesis" survived the eighteenth century nicely in spite of the fact that spermatozoa had been discovered and in spite of the competition offered by preformationism. It is true that its popularity may have declined somewhat but it had been so universally accepted during the preceding two

centuries that it had sufficient momentum to carry it along. Its popularity showed a further decline in the early nineteenth century perhaps because it suffered from the skepticism which Lamarck had unintentionally introduced into the question of the inheritance of acquired characters. It did not disappear from scientific literature by any means but its relative frequency declined. Only two instances of its use prior to its revival by Charles Darwin will be cited.

The first is a passage in *Allegemeine Naturgeschichte* (1839-1841) by LORENZ OKEN. The following quotation is from the English edition, *Elements of physiology*, London, 1847. From p. 191:

Only from an organic menstruum can a new organism proceed, but not one organism out of the other. A finished or perfect organism cannot gradually transform itself into another.

The generative juices, or semen and vitellus, are none other than the total organism reduced to the primary menstruum.

. . . but the semen is the product of the whole body. Through the semen the whole body, rendered fluid or reduced to the primary form, runs away. The semen is the chyle already prepared for all parts; but because it is in a sexual animal, it thus takes the reverse direction and passes out.

A fluid, in which the whole mass has been dissolved, is parallel to the nerve—or point-mass. The semen is a fluid point or nerve-mass, the fluid brain.

Even what is spiritual directly resides in the semen; it need only assume a form and the cerebral functions commence.

Oken repeated this passage on p. 481.

The second instance occurred in HERBERT SPENCER'S *Principles of biology*, London, 1863-1864. Spencer invented certain "physiological units" which corresponded very closely to Darwin's gemmules, a fact which Darwin recognized when it was called to his attention. Spencer's interpretation of pangenesis is in Ch. VIII:

. . . It involves a denial of the persistence of force to say that A may be changed into A', and may yet beget offspring exactly like those it would have begotten had it not been so changed. That the change in the offspring must, other things equal, be in the same direction as the change in the parent, we may dimly see is implied by the fact, that the change propagated throughout the parental system is a change towards a new state of equilibrium—a change tending to bring the actions of all organs, reproductive included, into harmony with these new actions. Or, bringing the question to its ultimate simplest form, we may say that as, on the one hand physiological units will, because of their special polarities, build themselves into an organism of a special structure; so, on the other hand, if the structure of this organism is modified by modified function, it will impress some corresponding modification on the structures and the polarities of its units. The units and aggregate must act and re-act on each other. The forces exercised by each unit on the aggregate and by the aggregate on each unit, must ever tend towards a balance. If nothing prevents, the units will mould the aggregate into a form in equilibrium with their pre-existing polarities. If contrariwise, the aggregate is made by the incident actions to take a new form, its forces must tend to remould the units into harmony with this new form.

Three years after Spencer, DARWIN (1868) published his hypothesis of pangenesis in *Animals and plants under domestication* (p. 92). Here it was assigned a major role in the causation of evolution. Its acceptance was by no means universal but it stood up well until the last quarter of the nineteenth century when Weismann discovered the continuity of the germ plasm. Even then it did not die and numerous instances of its acceptance by leading scientists can be found up to the beginning of the twentieth century. Then the discovery of Mendel's forgotten work put the whole matter on a new basis and pangenesis came to the end of its 2300-year career.

## CONCLUSION

The inheritance of acquired characters is so naïvely reasonable and explains so much so easily that we should not be astonished to find it firmly embedded in our earliest writings. The neolithic or bronze-age observer had only to notice that animals and plants were modified when their environments were altered and that children more or less tend to resemble their parents. These two observations should have suggested the doctrine rather forcibly to his attention. Of course, in the absence of any notion that there might be a distinction between congenital and environmentally induced variations we would expect him to accept the inheritance of acquired characters without question. Indeed, the story of Phaëthon which explains how the Ethiopians became black antedates written records. Incidentally, it differs from the eighteenth-century anthropological explanations chiefly in the fact that it makes the changes occur in a single generation. Otherwise it is in agreement with the accounts given by Strabo (7 B.C.), St. Athanasius of Alexandria (296–373), Voss (1658), Rumpf (1721), Mitchell (1744), Maupertuis (1745), Camper (1764), Josephi (1770), Hunter (1775), Blumenbach (1775), Zimmermann (1778), Herder (1784), Sömmering (1785), and Smith (1787).

The inheritance of acquired characters was also involved in the theological problem of the transmission of original sin. Adam's descendants became mortal as an effect of his disobedience. Also the sins of the fathers were to be visited upon the children (Exodus 20: 5; 34: 7) but later this was expressly denied (Jeremiah 31: 29, 30; Ezekiel 18: 2, 3). The denial, however, was purely on ethical grounds. Euripides but not Plutarch (*Those whom the Gods are slow to punish*) considered the gods unjust when they punished children for the fathers' sins. Nevertheless the problem persisted well into the Middle Ages and Roger Bacon (1268) explained the shortened lives of his contemporaries as due to the debilitating effects of many generations of sinful living.

The best known classical use of the inheritance of acquired characters is Hippocrates' (400 B.C.) expla-

nation of how the heads of the Macrocephali became long and narrow. Other classical authorities who accepted this doctrine were Aristotle (384–321 B.C.), Antigonus (285–247 B.C.), Galen (A.D. 130–220), Solinus (A.D. 235–300) and Justinus (A.D. 400).

For the eight hundred years following the fall of the Western Roman Empire few, if any, evidences of a belief in the inheritance of acquired characters are to be found. In the thirteenth century, however, it was the accepted doctrine and was held by St. Thomas Aquinas, St. Albertus Magnus, and Roger Bacon, and in the next century it was endorsed by Pierre Bersuire (d. 1362).

In the sixteenth century the belief in the inheritance of acquired characters was universal. It was used by Elyot (1539) and Cogan (1596) to explain how fruit, the original food of all mankind, no longer suited the human constitutions. It was accepted by Polydore Vergil (1550) as the explanation of the inherited effects of Divine punishment, and it was used by Jerome Cardan (1550) in a number of instances. Cardan relied upon it to explain how some American Indians were born with flat heads, how dolphins grew to like being called by the name, "Simon," how his little bitch inherited the education of her parents and learned to fetch and carry and, finally, how disease was inherited. Jacques DuBois (1551) called upon the belief to account for the disappearance of the intermaxillary bone from the human skull, which had happened, he said, since the time of Galen. During this century, the doctrine also was indorsed by Vesalius (1543) Rueff (1554), Lemnius (1561), Scaliger (1566), Paré (1573), Donatus (1584), Seidel (1593), and del Rio (1599).

How widespread the belief in the inheritance of acquired characters was during the seventeenth century can be shown most simply by citing the records in chronological order, as follows: Bauhin (1614), Zara (1615), de Meara (1619), Burton (1621), Borel (1636), Digby (1645), Highmore (1651), Voss (1658), Reys (1661), Le Grand (1672), Pechlin (1677), Hale (1677), Burnet (1681), and John Ray (1691).

In the eighteenth century the inheritance of acquired characters was used most widely to account for the existence of different human races. At this time it was thought that all men were descended from Noah, so the origin of the racial differences, which explorers and travelers saw, had to be explained. The eighteenth-century anthropologists, who relied upon the doctrine for their explanation, have been listed above. Their contemporaries who used the doctrine for other purposes included Wirth (1734), Buffon (1750), Herbert (1755), Adanson (1763), Gregory (1766), Oliver Goldsmith (1774), Lord Monboddo (1774), G. Forster (1777), J. R. Forster (1778), Meiners (1785), Voigt (1789), Condorcet (1793), Erasmus Darwin (1794), Ludwig (1796), and Goodwin (1797).

At the beginning of the nineteenth century, Lamarck used the inheritance of acquired characters to explain evolution, and his contribution to biological theory consists in this application of the ancient and generally accepted doctrine. It is true that Erasmus Darwin had anticipated him, but Lamarck was the first who actually called the possibilities of the doctrine to the attention of the biological world. Unfortunately, the examples he cited to illustrate the process of evolution had in them more than a touch of the ridiculous, so he really accomplished very little and only brought his hypothesis into disrepute. His reputation was not rescued until after Charles Darwin published the *Origin of species* (1859). However, some early nineteenth-century scientists still believed in the inheritance of acquired characters; among these were Sir Charles Lyell (1833), Haldeman (1844), Chambers (1844), Cabell (1859), Herbert Spencer (1864), and, of course, Charles Darwin (1868).

While the inheritance of acquired characters was a most ancient, honorable and dominant doctrine, some little skepticism persisted. As has been stated, Jeremiah and Ezekiel rejected the belief on moral grounds. Aristotle stated that mutilations, at least, were not always inherited, although he believed that acquired characters were. On the other hand, Lucretius (99–55 B.C.) denied this type of inheritance explicitly. St. Thomas Aquinas, like Aristotle, stated that some mutilations were not heritable while his contemporary, Vincent of Beauvais denied that any were. L. P. (1695), an anonymous scholar of Oxford, denied that accidental colors were inherited. Likewise, Charles Bonnet (1763) denied the inheritance of mutilations even if they were repeated for many generations. Lord Kames (1774) rejected the doctrine of the inheritance of acquired characters, as did Immanuel Kant (1785) and Charles White (1799). Lamarck's famous use of the doctrine did not add to its prestige and it was rejected by Pritchard (1808) and Lawrence (1819).

The only explanation offered for the inheritance of acquired characters was pangenesis. In classical times pangenesis was used in its simplest form, the semen was merely derived from the whole body with no details given. In several passages Hippocrates (ca. 400 B.C.) stated the doctrine explicitly. He was probably anticipated by both Anaxagoras and Diogenes of Apollonia but the fragments of their work which still exist are too incomplete to contain the whole doctrine. His contemporary, Democritus, however, accepted pangenesis. Aristotle denied the doctrine on the grounds that such solid parts of the body as the hair and the nails could not contribute material to the semen but in the pseudo-Aristotelian *Problems* pangenesis is endorsed. It was also accepted by Epicurus (341–271 B.C.), Sphaerus (230 B.C.), Lucretius (99–55 B.C.), Plutarch (A.D. 46–125), and Galen (A.D. 130–220). Several of the early fathers of the Church joined with their pagan contemporaries in using pangenesis to explain the origin

of semen, although their descriptions of the process were rarely precise. Those who described pangenesis in whole or in part during the next three centuries are Clement of Alexandria (ca. 193–211), Censorinus (ca. 238), Nemesius (ca. 275–300), Lactantius (260–340) and St. Augustine (345–430). During the next eight hundred years we have but two indorsements of pangenesis, those of St. Isidore of Seville (622) and Ibn Sina (980–1037).

In the thirteenth century the doctrine of pangenesis was greatly elaborated and discussed in much detail. The form in which it was accepted, however, was Buffonian rather than Darwinian, that is, the semen was supposedly the completely refined, excess food taken into the body. The various parts of the body merely separated out of the nutriment the exact material out of which they were built and sent this excess material to the semen. Darwin's hypothesis differed from this in that he assumed that the parts of the body produced the semen from themselves. Those who described pangenesis in this century were Bartholomew the Englishman, William of Auvergne, St. Thomas of Aquinas, St. Albert the Great, Vincent of Beauvais, and Roger Bacon.

Peter of Crescenzi wrote the *Opus ruralium commodorum* in 1305 and pangenesis appears in some of the later printed editions of this work. It would be difficult to determine just when the doctrine was inserted, as it is not to be found in some of the earlier editions.

In the fifteenth century, pangenesis became incorporated in medical literature, particularly in works dealing with the diseases of women. The works of Zeno (1491), Ficino (1492), and Peyligk (1499) may be cited as examples. Leonardo da Vinci (1452–1519) also indorsed pangenesis. In the sixteenth century it appeared in practically every medical treatise on gynaecology. The records from this century are merely cited in chronological order: Valla (1501), Bonaciolus (1502), Reisch (1504), Maffei (1506), Richerius (1516), Paracelsus (ca. 1526), Niphus (1526), DuBois (1530), Pictorius (1530), de la Roche (1542), Vicary (1548), Cardan (1550), Akakia (1551), Pantinus (1552), Rueff (1554), Belon (1555), Fernel (1497–1558), Lemnius (1561), Scaliger (1566), Paré (1573), Peramato (1576), Mercuriale (1582), Donatus (1584), Corde (1585), Bottoni (1585), Piccolomini (1586), Montaltus (1591), Seidel (1593), Cogan (1596), and Vaughan (1600).

Pangenesis continued to appear in the medical literature of the seventeenth century and, in addition, it was used frequently in the more philosophical works to explain the inheritance of acquired characters and of disease. Again the records are merely cited in order: Castro (1603), Bauhin (1614), Zara (1615), de Meara (1619), Burton (1621), and Cornerus (1627). Carranza (1629) denied the doctrine but it was accepted by Borel (1636), Digby (1645), Highmore

(1651), Ross (1652), Sinibaldus (1652), Horstius (1660), Le Grand (1672), Venette (1683), Kestler (1686), Malpighi (1687), Ray (1691), and Dionis (1698).

In the eighteenth century pangenesis continued to flourish in medical and biological literature. It was the stock hypothesis to explain the inheritance of disease, although it was somewhat separated from the doctrine of the inheritance of acquired characters, as the latter was used more and more in the anthropological literature. Among those who accepted pangenesis are Hartmann (1716), Perrault (1721), Gorter (1725), Wirth (1734), Réaumur (1749), Needham (1750), Buffon (1750), Maupertuis (1751), Rey (1752), deLaunay (1754), Diderot (1754), Bonnet (1781), and von Haller (1781). Pangenesis was denied by Erasmus Darwin (1794).

In the nineteenth century pangenesis was described by Lorenz Oken (1847) and Herbert Spencer (1864). Four years after Spencer, Charles Darwin (1868) invented the name, "pangenesis," which was brought into the literature of evolution. Although challenged by Weismann and his followers, the doctrine had adherents until Mendel's work was rediscovered at the beginning of the twentieth century.

The writer wishes to express his obligation to Mr. David Goodman, Mr. Arthur Zeben, and Mr. Robert Schettler, who have translated most of the quoted passages, which have not appeared previously in English editions, and to Dr. Alexander Pogo who has read the manuscript and has contributed numerous valuable suggestions.

## REFERENCES

- ADANSON, MICHEL. 1763. Familles des plantes. Paris.
- AKAKIA, MARTIN. 1597. De morbis muliebribus. In *Gynaeciorum etc.* ed. by Israel Spachius). Strassburg.
- ANTIGONUS, CARYSTIUS. 1791. *Historiarum mirabilium collectanea*. Leipzig.
- ARISTOTLE. 1910. *History of animals* (tr. by D. W. Thompson). Oxford.
- 1910. *Generation of animals* (tr. by Arthur Platt). Oxford.
- AVICENNA, see Ibn Sina.
- BACON, ROGER. 1911–1930. *Liber primus communium naturalium*. Oxford.
- 1928. *Opus majus* (tr. by R. B. Burke). Philadelphia.
- BARTHOLOMEW THE ENGLISHMAN. 1495. *All the propytees of thynges* (tr. by John Trevisad). Westminster.
- BAUHIN, CASPAR. 1614. *De hermaphroditorum monstrosorumque partuum natura*. Oppenheim.
- 1635. *Theatrum anatomicum*. Frankfurt.
- BELON, PIERRE. 1555. *L'histoire de la nature des oyseaux*. Paris.
- BERSUIRE, PIERRE. 1575. *Reductorium morale*. Venice.
- BLUMENBACH, JOHANN FRIEDRICH. 1775. *De generis humani varietate nativa*. Göttingen.
- 1795. *Elements of physiology*. Philadelphia.
- 1865. *The anthropological treatises of J. F. Blumenbach* (tr. by Thomas Bendysche). London.
- BONACIOLUS, LOUIS. 1502. *Enneas muliebris* Ferrara.
- BONNET, CHARLES. 1781. *Oeuvres d'histoire naturelle*. Neuchâtel.
- BOREL, PIERRE. 1656. *Historiarum et observationum medico-physicarum centuriae*. Paris.
- BOTTONI, ALBERTINO. 1585. *De morbis muliebribus*. Padua.
- BROCK, J. 1888. Einige ältere Autoren über die Vererbung erworbenner Eigenschaften. *Biol. Centralbl.* 8: 491–499, 1888.
- BROOKS, W. K. 1887. *The laws of heredity*. Baltimore.
- BROWNE, SIR THOMAS. 1646. *Pseudodoxia epidemica*. London.
- BUFFON, GEORGES LOUIS LECLERC DE. 1791. *History of animals* (tr. by W. Smellie). London.
- 1749–1804. *Histoire naturelle*. Paris.
- 1812. *Natural history general and particular* (tr. by William Wood). London.
- BURNET, JAMES. 1774. *Of the origin and progress of language*. London.
- BURNET, THOMAS. 1681–1689. *The sacred theory of the earth*, ed. of 1719. London.
- BURTON, ROBERT. 1621. *Anatomy of melancholy*. London.
- CABELL, J. L. 1859. *The testimony of modern science to the unity of mankind*. New York.
- CAMPER, PIERRE. 1803. *Oeuvres*. Paris.
- CARDAN, JEROME. 1663. *Opera omnia*.
- CARRANZA, ALONSO. 1629. *Tractatus . . . de partu naturali et legitimo*. Geneva.
- CASTRO, RODERICUS A. 1603. *De universa mulierum medicina*. Hamburg.
- CENSORINUS. 1587. *De die natali*. Venice.
- CHOULANT, JOHANN LUDWIG. 1920. *History and bibliography of anatomic illustration*. Chicago.
- COGAN, THOMAS. 1596. *The haven of health*. London.
- COLE, F. J. 1930. *Early theories of sexual generation*. Oxford.
- CONDORCET, M. J. A. N. CARITAT, MARQUIS DE. 1794. *Equisse d'un tableau historique des progrès de l'esprit humain*. Paris.
- 1795. *Outlines of an historical view of the progress of the human mind*. London.
- CORDE, MAURICE. 1585. *Commentarii in librum priorem Hippocratis Coi de mulieribus*. Paris.
- CÖRNERUS, BALTHASAR. 1627. *De morbis haereditariis*. Wittenberg.
- DARWIN, CHARLES. 1868. *The variation of animals and plants under domestication*. New York.
- DARWIN, ERASMUS. 1794–1796. *Zoonomia: or, the laws of organic life*. London.
- 1788. *Phytologia*. London.
- 1802. *Temple of nature*. London.
- DARWIN, SIR FRANCIS, AND C. R. DARWIN. 1887. *Life and letters of Charles Darwin*. London.
- DIDEROT, DENIS. 1818. *Oeuvres complètes*. Paris.
- DIGBY, SIR KENELM. 1645. *Immortality of reasonable souls*. London.
- DIOGENES LAERTIUS. 1925. *Lives of eminent philosophers* (tr. by R. D. Hicks). London.
- DIONIS, PIERRE. 1698. *Dissertation sur la génération de l'homme*. Paris.
- 1718. *Traité général des accouchemens*. Paris.
- DONATUS, MARCELLUS. 1584. *De medica historia mirabili*. Mantua.
- DUBOIS, JACQUES. 1530. *De hominis generatione, sive foecunditatis et sterilitatis causis*. Geneva.
- 1551. *Vesani cuiusdam calumniarum in Hippocratis & Galeni rem anatomicam*. Paris.
- EBERS, GEORGE. 1884. *The Papyrus Ebers, the earliest medical work extant*. New York.
- ELYOT, SIR THOMAS. 1539. *The castel of helth*. London.
- FERNEL, JEAN. 1593. *Universa medicina*. Lyons.
- FICINO, MARSIGLIO. 1561. *Opera*. Basel.
- FORSTER, GEORGE. 1777. *A voyage round the world*. London.
- 1786. Noch etwas über die Menschenrassen *Der teutsch Merkur* 4: 57–86.
- 1789. Ein Beytrag zur Völker- und Länderkunde, usw. Leipzig.
- FORSTER, JOHN REINHOLD. 1778. *Observations made during a voyage round the world*. London.
- GALEN. 1821–1833. *Opera omnia*. Leipzig.
- GASSENDI, PIERRE. 1649. *Animadversiones in decimum librum Diogenis Laertii; qui est de vita, moribus, placitisque Epicuri, etc.* Lyons.
- GODWIN, WILLIAM. 1797. *The enquirer*. London.
- GOLDSMITH, OLIVER. 1744. *History of the earth and animated nature*. London.
- GORTER, JOANNES DE. 1725. *De perspiratione insensibili*. Padua.
- GRAPALDUS, FRANCISCUS MARIUS. 1506. *De partibus aedium*. Parma.
- GREGORY, JOHN. 1778. *A comparative view of the state and faculties of man with those of the animal world*. Dublin.
- HALDEMAN, SAMUEL STEDMAN. 1844. Enumeration of the recent freshwater molluscs which are common to North America and Europe with observations on species and their distribution. *Boston Jour. Nat. Hist.* 4: 468–484.
- HALE, SIR MATTHEW. 1677. *The primitive origination of mankind*. London.
- HALLER, ALBRECHT VON 1766–1778. *Elementa physiologiae corporis humani*. Lausanne.
- 1803. *First lines of physiology*. Troy.
- HARTMANN, FRANZ. 1887. *The life of . . . Paracelsus*. London.
- HARTMANN, GEORGIUS VOLCMARUS. 1716. *De generatione*. Erfurt.

- HENERUS, RENATUS. 1555. *Adversus Jacobi Sylvii . . . calumnias*. Venice.
- HERBERT, CLAUDE JAQUES. 1755. *Essai sur la police générale des grains*. Paris.
- HERDER, JOHANN GOTTFRIED. 1784. *Ideen zur Philosophie der Geschichte der Menschheit*. Riga and Leipzig.
- 1803. *Outlines of the philosophy of the history of man* (tr. by T. Churchill). London.
- HIGHMORE, NATHANIEL. 1651. *The history of generation*. London.
- HIPPOCRATES. 1839. *Oeuvres complètes*. Paris.
- 1886. *The genuine works of Hippocrates* (tr. by Francis Adams). New York.
- HOME, HENRY. 1774. *Sketches in the history of man*. Edinburgh.
- HORSTIUS, GREGORY. 1660. *Opera medica*. Norimbergae.
- HUNTER, JOHN. 1775. *Disputatio inauguralis quaedam de hominum varietatibus et harum causis*. Edinburgh.
- 1865. *An inaugural dissertation* (tr. by Thomas Bendyshe). London.
- IBN SINA. 1658. *Canon medicinae*. Louvain.
- JOHANNSEN, W. 1917. *Die Vererbungslehre bei Aristoteles und Hippokrates im Lichte heutiger Forschung*. *Naturwissenschaften* 5: 389-397.
- JOSEPHI, WILHELM. 1770. *Grundniss der Naturgeschichte des Menschen*. Hamburg.
- JUSTINUS. 1746. *The history of the world* (tr. by S. Turnbull). London.
- KAMES, LORD, see Henry Home
- KANT, IMMANUEL. 1839. *Bestimmung des Begriffs einer Menschenrace*. Leipzig.
- KEMPIUS, CORNELIUS. 1588. *De origine . . . Frisiae*. Cologne.
- KESTLERUS, JOANNES STEPHANUS. 1680. *Physiologia Kircheriana experimentalis*. Amsterdam.
- KIPLING, RUDYARD. 1902. *Just so stories*. New York.
- KRUMBIEGEL, INGO. 1933. *Die prämendelistische Vererbungs-forschung und ihre Grundlagen*. *Bibliogr. Genetica* 10: 251-298.
- LACTANTIUS. 1886. *The workmanship of God* (tr. by W. Fletcher). Buffalo.
- LAMARCK, J. B. P. A. DE MONET DE. 1802. *Recherches sur l'organisation des corps vivants*. Paris.
- 1873. *Philosophie zoologique*. Paris.
- 1914. *Philosophical zoology* (tr. by Hugh Elliot). London.
- 1815-1822. *Histoire naturelle des animaux sans vertèbres*. Paris.
- 1801. *Système des animaux sans vertèbres*. Paris.
- LA ROCHE, NICOLAS DE. 1542. *De morbis mulierum curandis*. Paris.
- DE LAUNAY, CHARLES DENYS. 1754. *Nouveau système sur la génération de l'homme*. Paris.
- LAWRENCE, WILLIAM. 1819. *Lectures on the natural history of man*. London.
- LE GRAND, ANTOINE. 1673. *Historia naturae, variis experimentis et ratiociniis elucidatae, etc.* London.
- 1672. *Institutio philosophiae secundum principia Renati Descartes*. London.
- LEMNIUS, LEVINUS. 1559. *Occulta naturae miracula*. Antwerp.
- LEONARDO DA VINCI. 1938. *Notebooks* (ed. and tr. by E. MacCurdy). New York.
- LOCY, WILLIAM A. 1925. *The growth of biology*. New York.
- LUCRETIUS. 1929. *On the nature of things* (tr. by Thomas Jackson). Oxford.
- LUDWIG, CHRISTIAN FRIEDRICH. 1796. *Grundriss der Naturgeschichte der Menschenspecies*. Leipzig.
- LYELL, SIR CHARLES. 1832. *Principles of geology*. London.
- MCCARTHY, E. S. 1937. *Acquired and transmitted characters in Greek lore of heredity*. *Papers Mich. Ad. Sci. Arts & Letters* 7: 21-40.
- MAFFEIUS, RAPHAEL. 1552. *Commentariorum urbanorum . . . libri*. Lyons.
- DE MAILLET, BENOIT. 1797. *Telliamed*. Baltimore.
- MALPIGHI, MARCELLO. 1686. *Opera omnia*. London.
- DE MAUPERTUIS, PETER LOUIS MOREAU. 1756. *Oeuvres*. Lyon.
- MAY, W. 1917. *Antike Vererbungstheorien*. *Naturw. Wochenschr. n.F.* 16: 9-10.
- MEARA, DERMITIUS DE. 1619. *Pathologia haereditaria generales*. Dublin.
- MEINERS, CHRISTOPH. 1785. *Grundriss der Geschichte der Menschheit*. Lemgo.
- MERCURIALE, GIROLAMO. 1582. *De morbis muliebribus*. Venice.
- MEYER, HANS. 1918. *Das Vererbungsproblem bei Aristoteles*. *Philologus* 75: 323-363.
- MITCHELL, JOHN. 1744. *An essay upon the causes of the different colours of people in different climates*. *Phil. Trans. Roy. Soc. London* 43: 103-150.
- MONBODDO, LORD, see James Burnet.
- MONTALTUS, HIERONYMUS. 1591. *De homine sano*. Frankfurt.
- NEEDHAM, JOHN TURBERVILLE. 1748. *A summary of some late observations upon the generation, composition and decomposition of animal and vegetable substance*. *Phil. Trans. Roy. Soc. London* 45: 614-666.
- NEEDHAM, JOSEPH. 1934. *A history of embryology*. Cambridge.
- NEMESIUS. 1565. *De natura hominis*. Antwerp.
- NIPHUS, AUGUSTINUS. 1641. *De amore*. Leyden.
- OKEN, LORENZ. 1839-1841. *Allgemeine Naturgeschichte*. Stuttgart.
- 1847. *Elements of physiophilosophy*. London.
- OSBORN, H. F. 1894. *From the Greeks to Darwin*. New York.
- P., L. 1814. *Two essays sent in a letter from Oxford to a nobleman in London. The first concerning some errors about the creation, general flood and the peopling of the world, etc.* *Somers Tracts* (2nd ed.) 12: 20-33.
- PANTINUS, GULIELMUS. 1552. *Comments in Aulus Cornelius Celsus: De arte medica*. Basel.
- PARACELUS. 1668. *Opera omnia*. Geneva.
- PARÉ, AMBROISE. 1573. *De hominis generatione*. Paris.
- 1634. *Works* (tr. by T. Johnson). London.
- PECHLIN, JOHANN NICOLAUS. 1677. *De habitu et colore Aethiopum*. Kiel.
- PERAMATO, PETRO DE. 1576. *De facultatibus nostrum corpus dispensantibus*. Sanlucar a Barrameda.
- PERRAULT, CLAUDE ET PIERRE. 1721. *Oeuvres diverses de physique et mécanique*. Leiden.
- PETER OF CRESCENZI, see Petrus de Crescentiis.
- PETRUS DE CRESCENTIIS. 1602. *New feldt und ackerbaw*. Strassburg.
- PEYLIQK, JOHANNES. 1499. *Philosophiae naturalis compendium*. Leipzig.
- PICCOLOMINI, ARCHANGELO. 1586. *Anatomicae praelectiones*. . . Rome.
- PICTORIUS, GEORGIUS. 1558. *Dialogi*. Paris.
- PLINY. 1602. *The historie of the world* (tr. by Holland). London.
- PLUTARCH. 1909. *Concerning such whom God is slow to punish* (tr. by John Philips). Boston & New York.
- 1909. *Essays and miscellanies*. Ed. by A. H. Clough and W. N. Goodwin. 5 v. Boston & New York.
- PRICHARD, JAMES COWLES. 1808. *De generis humani varietate*. Edinburgh.
- 1813-1826. *Researches into the physical history of man*. London.
- PSELLUS, MICHAEL. 1718. *De omnifaria doctrina*. Hamburg.
- PSEUDO-ARISTOTLE. 1936-1937. *Problems* (tr. by W. S. Hett). London.
- RAY, JOHN. 1691. *The wisdom of God manifested in the works of creation*. London.

- RÉAUMUR, RÉNÉ ANTOINE DE. 1749. *Art de faire éclore . . . des oiseaux domestiques*. Paris.
- REISCH, GREGORIUS. 1503. *Margarita philosophica*. Freiburg im Breisgau.
- REY, GUILLAUME. 1752. *Discours sur la transmission des maladies héréditaires*. Paris.
- REYS-FRANCO, GASPARD DOS. 1661. *Elysium jucundarum quaestionum campus*. Brussels.
- RHODIGINUS, see Ludovicus Coelius Richerius.
- RICHERIUS, LUDOVICUS COELIUS. 1516. *Sicuti antiquarum lectionum commentarios . . .* Venice.
- RIO, MARTINUS ANTONIUS DEL. 1599. *Disquisitiones magicae*. Louvain.
- ROSS, ALEXANDER. 1651. *Arcana microcosmi: or, the hid secrets of man's body disclosed . . .* London.
- RUEFF, JAKOB. 1554. *De conceptu et generatione hominis*. Zurich.
- RUMPF, VINCENTIUS. 1721. *Dissertatio critica de hominibus orbis nostri incolis, specie et ortu*. Hamburg.
- ST. ALBERT, see St. Albertus Magnus.
- ST. ALBERTUS MAGNUS. 1890-1899. *Opera omnia*. Paris.
- ST. ATHANASIUS OF ALEXANDRIA. 1857. *Opera omni quae extant (Migne XXV-XXVIII)*. Paris.
- ST. AUGUSTINE. 1894. *De genesi ad litteram*. Leipzig.
- 1868-1888. *Marriage and concupiscence* (tr. by Peter Holmes). New York.
- ST. CLEMENT OF ALEXANDRIA. 1886. *The instructor* (tr. by Alexander Roberts). Buffalo.
- ST. GREGORY OF COSTANTINOPLE. 1862-1888. *Scholia* (Migne collection, ser. 2, II: 911). Paris.
- ST. ISIDORE OF SEVILLE. 1911. *Etymologiae*. Oxford.
- ST. THOMAS AQUINAS. 1911-1917 *Opera omnia*. London.
- 1912. *Summa theologiae*. London.
- SCALIGER, JULIUS CAESAR. 1566. *Commentarii et animadversiones . . . de causa plantarum Theophrasti*. Geneva.
- 1557. *De subtilitate*. Paris.
- SCHENCK, JOHANNES. 1609. *Observationum medicarum rariorum libri VII*. Frankfurt.
- SEIDEL, BRUNO. 1593. *De morborum incurabilium causis*. Frankfurt.
- SINIBALDUS, JOHANNES BENEDICTUS. 1642. *Geneanthropeiae sive de hominis generatione*. Roma.
- SMITH, SAMUEL STANHOPE. 1787. *An essay on the causes of varieties of complexion and figure in the human species*. Philadelphia.
- SOLINUS, GAIVS JULIUS. 1777. *Solini polyhistor* (ed. of Salmasius). Leipzig.
- SÖMMERRING, SAMUEL THOMAS VON. 1785. *Über die körperliche Verschiedenheit des Negers vom Europäer*. Frankfurt und Mainz.
- SPENCER, HERBERT. 1863-1864. *Principles of biology*. London.
- STIEBITZ, F. 1930. *Über die Kausalerklärung der Verebung bei Aristoteles* *Archiv. Gesch. Med.* 23: 332-345.
- STRABO. 1903-1906. *Geography* (tr. by H. C. Hamilton). London.
- SUDHOFF. 1909. *Geschichte der Anatomie im Mittelalter*. Leipzig.
- SUETONIUS. 1899. *History of twelve Caesars* (tr. by Philemon Holland). London.
- SYLVIVS, JACOBUS, see Jacques DuBois.
- THOMPSON, J. ARTHUR. 1889. *History and theory of heredity*. *Proc. Roy. Soc. Edinb.* 16: 91-116.
- VALLA, GEORGE. 1501. *De expetendis et fugiendis rebus opus*. Venice.
- VAUGHAN, WILLIAM. 1600. *Directions for health natural and artificiall*. London.
- VENETTE, NICOLAS. 1687. *La génération de l'homme ou tableau de l'amour conjugal*. Amsterdam.
- VERGIL, POLYDORE. 1651. *Historiae Anglicae*. Leyden.
- VESALIUS, ANDREAS. 1543. *De humani corporis fabrica*. Basel.
- VICARY, THOMAS. 1548. *The anatomie of the bodie of man*. London.
- VINCENT OF BEAUVAIS. 1481. *Speculum naturale*. Basel.
- VOIGT, HEINRICH JOHANN. 1789. *J. Fr. Blumenbach, über Künsteleyen oder zufällige Verstümmelungen am thierischen Körper, die mit Zeit zum erblichen Schlag ausgeartet*. *Mag. Neuste Physik Naturgeschichte* 6 (1): 13.
- VOSS, ISAAC. 1658. *Comments on De situ orbis of Pomponius Mela*. The Hague.
- WHITE, CHARLES. 1799. *An account of the regular gradations in man and in different animals and vegetables and from the former to the latter*. London.
- WILLIAM OF AUVERGNE. 1516. *Operum summa . . .* Paris.
- WIRTH, TOBIAS. 1734. *De morbis haereditariis*. Copenhagen.
- ZARA, ANTONIO. 1615. *Anatomia ingeniorum et scientiarum*. Venice.
- ZENO, ANTONIO (POLICALA). 1491. *De natura humana*. Venice.
- ZIMMERMANN, E. A. W. VON. 1778-1783. *Geographische Geschichte des Menschen . . .* Leipzig.
- ZIRKLE, CONWAY. 1935. *The inheritance of acquired characters and the provisional hypothesis of pangenesis* *Amer. Nat.* 69: 417-445.
- 1936. *Further notes on pangenesis and the inheritance of acquired characters*. *Amer. Nat.* 70: 529-546.

## INDEX OF AUTHORS CITED

- Adanson, Michel, 107  
 Akakia, Martin, 131  
 Anaxagoras, 120  
 Antigonus, Carystus, 94  
 Aristotle, 94, 121  
 Avicenna (see Ibn Sina)
- Bacon, Roger, 96, 127  
 Bartholomew the Englishman, 124  
 Bauhin, Caspar, 101  
 Belon, Pierre, 131  
 Bersuire, Pierre, 97  
 Blumenbach, Johann Friedrich, 98, 110  
 Bonaciolus, Ludovicus, 128  
 Bonnet, Charles, 107, 143  
 Borel, Pierre, 103  
 Bottoni, Albertino, 133  
 Brooks, W. K., 120  
 Browne, Sir Thomas, 102  
 Buffon, George Louis Leclerc de, 107, 141  
 Burnet, James, 109  
 Burnet, Thomas, 104  
 Burton, Robert, 101
- Cabell, J. L., 118  
 Camper, Pierre, 108  
 Cardan, Jerome, 98, 130  
 Carranza, Alonso, 135  
 Castro, Rodericus à, 134  
 Censorinus, 122  
 Choulant, Johann Ludwig, 120  
 Cogan, Thomas, 100, 134  
 Cole, F. L., 134  
 Condorcet, M. J. A. N. Caritat, Marquis de, 114  
 Corde, Maurice, 133  
 Córnerus, Balthasar, 135
- Dante, 120  
 Darwin, Charles, 92, 119, 144  
 Darwin, Erasmus, 115, 144  
 Democritus, 121  
 Diderot, Denis, 143  
 Digby, Sir Kenelm, 102, 120, 136  
 Diogenes of Apolonia, 121  
 Diogenes Laertius, 121  
 Dionis, Pierre, 138  
 Donatus, Marcellus, 100, 133  
 DuBois, Jacques, 98, 130
- Ebers, George (see *The Papyrus Ebers*)  
 Elyot, Sir Thomas, 97  
 Epicurus, 121  
 Exodus, 93  
 Ezekiel, 93
- Fernel, Jean, 132  
 Ficino, Marsiglio, 128  
 Forster, George, 111  
 Forster, John Reinhold, 111
- Galen, 95  
 Gassendi, Pierre, 102, 137  
 Godwin, William, 115  
 Goldsmith, Oliver, 108  
 Gorter, Joannes de, 139
- Grapaldus, Franciscus Marius, 129  
 Gregory, John, 108
- Haldeman, Samuel Stedman, 118  
 Hale, Sir Matthew, 104  
 Haller, Albrecht von, 142  
 Hartmann, Georgius Volcmarus, 139  
 Henerus, R., 99  
 Herbert, Claude Jaques, 107  
 Herder, Johann Gottfried, 112  
 Highmore, Nathaniel, 102, 137  
 Hippocrates, 93, 120, 121  
 Home, Henry, 109  
 Horstius, Gregory, 137  
 Hunter, John, 109
- Ibn Sina, 123
- Jeremiah, 93  
 Josephi, Wilhelm, 108  
 Justinus, 95
- Kames, Lord (see Henry Home)  
 Kant, Immanuel, 113  
 Kempius, Cornelius, 100  
 Keslerus, Joannes Stephanus, 138  
 Kipling Rudyard, 92
- Lactantius, 123  
 Lamarck, J. B. P. A. de Monet de, 91, 116  
 LaRoche, Nicolas de, 130  
 Launay, Charles Denys de, 142  
 Lawrence, William, 117  
 LeGrand, Antoine, 103, 137  
 Lemnius, Levinus, 99, 132  
 Leonardo da Vinci, 128  
 Locy, William A., 98  
 Lucretius, 94, 122  
 Ludwig, Christian Friedrich, 115  
 Lyell, Sir Charles, 118
- Maffei, Raphael, 129  
 Maillet, Benoit de, 106  
 Malpighi, Marcello, 138  
 Maupertuis, P. L. M. de, 106, 140  
 Meara, Dermitius de, 134  
 Meiners, Christoph, 113  
 Mercuriale, Girolamo, 132  
 Mitchell, John, 106  
 Monboddo, Lord (see James Burnet)  
 Montaltus, Heironymus, 133
- Needham, John Turberville, 141  
 Nemesius, 123  
 Niphus, Augustinus, 130
- Oken, Lorenz, 144  
 Osborn, Henry Fairfield, 91, 98
- P., L., 104  
 Pantinus, Gulielmus, 131  
*Papyrus Ebers*, 120  
 Paracelsus, 129  
 Paraeus, Ambrosius (see Ambroise Paré)  
 Paré, Ambroise, 99, 132  
 Pechlin, Johann Nicolaus, 104
- Peramato, Petro de, 132  
 Perrault, Claude, 105  
 Perrault, Pierre, 105  
 Peter of Crescenzi (see Petrus de Crescentiis)  
 Petrus de Crescentiis, 127  
 Peyligk, Johannes, 128  
 Piccolomini, Archangelo, 133  
 Pictorius, Georgius, 130  
 Pliny, 94  
 Plutarch, 94, 121, 122  
 Policola (see Antonio Zeno)  
 Prichard, James Cowles, 117  
 Psellus, Michael, 124
- Ray, John, 104, 138  
 Réaumur, René Antoine de, 140  
 Reisch, Gregorius, 129  
 Rey, Guillaume, 142  
 Reys-Franco, Gaspar dos, 103  
 Richerius, Ludovicus Coelius, 129  
 Rio, Martinus Antonius del, 100  
 Ross, Alexander, 137  
 Rueff, Jakob, 99, 131  
 Ruffus, Jacobus (see Jakob Rueff)  
 Rumpf, Vincentius, 105
- St. Albert the Great, 96, 126  
 St. Athanasius of Alexandria, 95  
 St. Augustine, 93, 123  
 St. Clement of Alexandria, 121, 122  
 St. Gregory of Constantinople, 120  
 St. Isidore of Seville, 123  
 St. Thomas Aquinas, 95, 125  
 Scaliger, Julius Caesar, 99, 132  
 Schenck, Johannes, 100  
 Seidel, Bruno, 100  
 Sinibaldus, Johannes Benedictus, 135  
 Smith, Samuel Stanhope, 113  
 Solinus, Gaius Julius, 95  
 Sömmerring, Samuel Thomas von, 113  
 Spencer, Herbert, 119, 144  
 Sphaerus, 122  
 Strabo, 94  
 Sudhoff, 120  
 Suetonius, 95  
 Sylvius, Jacobus (see Jacques DuBois)
- Valla, George, 128  
 Vaughan, William, 134  
 Venette, Nicolas, 138  
 Vergil, Polydore, 97  
 Vesalius, Andreas, 97  
 Vicary, Thomas, 130  
 Vincent of Beauvais, 96, 124  
 Voigt, Heinrich Johann, 114  
 Volaterranus (see Raphael Maffei)  
 Voss, Isaac, 103
- White, Charles, 116  
 William of Auvergne, 124  
 Wirth, Tobias, 105, 140
- Zara, Antonio, 101  
 Zeno, Antonio, 128  
 Zimmerman, E. A. W. von, 112