THE GENETIC THEORIES OF EMPEDOCLES

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BY some time in the fifth or fourth century B.C. (depending on how long the theory antedated the report of it in the psuedo-Hippocratic *On Diet*), Greek medical men in the eastern Mediterranean had developed a genetic combination-theory to explain how the sexual potencies carried by the "seeds" of male and female parents combined to determine the sexes of their children.[1] The most unsatisfactory aspect of this theory as a basis for anything approaching a scientific genetics was the fact of its *intransitivity*. The sex inherited by a parent was assumed to have no effect on the range of potencies which that parent's "seeds" would carry, hence if this combination technique were generalized to include other inherited traits, the heredity of a first generation would not be thought of as establishing any limitations on probabilities for the inherited traits of a second generation. While this approach might seem satisfactory so long as attention was confined to sex inheritance, it clearly will not explain how other traits are transmitted, such as eye-color and stature. These observations would show that the heredity of the parents does in fact set limitations and probabilities as to what the heredity of their children will be.

At this same time, and even earlier, the Greek medical school at Crotona, in the west, seems also to have been speculating about the mechanism of heredity. At some time close to 440 B.C., a combination theory of heredity, in which there was provision for the continuity of transmission of traits through successive generations was developed by the philosopher and scientist Empedocles, a native of Akragas, to explain the phenomena of "family resemblance" in physique and features.

Empedocles is a man who has never received just appreciation from posterity, because of his habit of merging fields and ideas which posterity has felt should be assiduously separated. Thus his synthesis of chemistry and metaphysics has not appealed to philosophers. His fusion of public health medicine with rites of religious purification has not seemed reasonable to doctors. His lyric poems on natural selection and the biological sciences have jarred the sensibilities of most later biologists and lyric poets alike.[2] On the other hand, Empedocles' experimental proof of the corporeality of air [detached from the speculative inferences he drew from the experiment] has often been cited as a landmark in the history of experimental science.

At any rate, the account that emerges from the reports and fragmentary direct quotations that we possess, is that of a keen and interested observer, eager to combine the insights of different specialists by what frequently seems to us an unwarranted excess of speculative imagination. If, in addition to being curious and speculatively imaginative, Empedocles was also vain, pompous, and superstitious, these traits are partly justified by his own contemporary importance in Sicily. They were partly inevitable in a product of the Western Greek cultural environment, and in any case do not seem to have intruded themselves in his scientific observations and speculations. This picture of the character of Empedocles is important for an understanding of the reconstruction of his theory which follows.

Censorinus' Account

Our account of the Empedoclean theory of family resemblance comes from Censorinus, writing much later.[3] Censorinus preserves a list of combinations (of the relative heat of the seeds contributed by each parent) which, he says, Empedocles used in the family-resemblance theory. But the interpretation attached to this list certainly is not the one that Empedocles intended.

In the first place, Censorinus represents the combinations as explaining the inheritance of

sex in the manner of the Hippocratic combination diagram. Actually we know, from the much more reliable report of Aristotle, that Empedocles had said sex-determination depended only on the temperature of the embryo's intrauterine location. Hence this was not an hereditary explanation of sex at all, rather an *environmental* explanation.[4] That Empedocles probably did hold such an environmentalist view is confirmed by the contemporaneous development of other environmental theories of sex-determination in the western Greek world.[5]

In the second place, Censorinus' interpretation takes no account of the *degree* to which family resemblance is inherited. It is quite incredible that some explanation of this easily observable variation was not given in Empedocles' original theory. Particularly is this so since this fact of variation in degree was the empirical evidence cited in defense of the theory of the medical school at Crotona.[6] Presumably at some point the influence of the eastern medical school led to a recasting of Empedocles' diagram, so that a list of sexes and resemblances, by assimilation with later current notions of sex-determination, was reinterpreted as a list of sexes of offspring and their resemblance to parents.

Philologically, such a reinterpretation would have been easy. Psychologically, at the hands of a scientist in whose mind combination patterns were firmly associated with sexual inheritance, this revision is easily understandable.

The matrix in Censorinus' version is:

		seed of female parent	
		HOT(H)	COLD(C)
seed of male parent	HOT	*HH*	*HC*
	COLD	*CH*	*CC*

HH—male child resembling male parent
HC—male child resembling female parent
CH—female child resembling male parent
CC—female child resembling female parent

More probably, the original interpretation ran:
HH—slightly resembling male parent [more than female line]
HC—strongly resembling male parent
CH—strongly resembling female parent
CC—slightly resembling female parent

In this reconstruction, the same matrix is used that the tradition had preserved; but the notion of hereditary determination of sex is not forced on Empedocles; and the relative potency of the two seeds is made the determinant of the nature and degree of inherited family resemblance. If this list were originally written in any abbreviated form, it could easily be read to make the sexes referred to alternately those of parent and child, instead of parent throughout.[7] Further, whatever terms were used for "weak" and "strong" could have seemed to such a paraphraser chemical characterizations, genetically irrelevant.

Since the sex of the child was determined, on Empedocles' theory, by its embryonic environment — "Hot" or "Cold," independent of any inherited appearance, the combinations as he saw them must have been:

		Embryonic Environment	
		Hot	Cold
HEREDITY*	*HH*	*M-r-M*	*F-r-M*
	HC	*M-R-M*	*F-R-M*
	CH	*M-R-F*	*F-R-F*
	CC	*M-r-F*	*F-r-F*

*heat of seed from each parent; male given first.

The first symbol, *M* or *F*, indicates the sex of the child, the third symbol the sex of the parent whose family line the child most resembles, and *r* and *R* whether there is a weak (*r*) or strong (*R*) degree of resemblance.

This theory combined for the first time several genetic insights, which, with a different subsequent history of medicine and philosophy, could have been of decisive importance. These are as follows:

1. Inherited traits are discrete and exclusive. On this point Empedocles' own philosophical theory of elements seems to have led him to diverge from the locally current opinion of his time that the traits inherited were an average of those possessed by the two parents. Instead, heredity of traits is here formulated as an alternative relation; either the child inherits resemblance to one parental family-line or to the other.

Both family lines determine the possible heredity of a child. This view is adapted from the current theories; it certainly contradicts the superstition some modern geneticists promulgate and hold, that the early Greeks thought traits were inherited from the male parent alone. This was the doctrine of only a few Greeks, and of none of the really early ones.

2. For the first time, a combination list is interpreted as transitive, that is, the heredity of the first generation limits the possible traits which that generation can transmit to the second, and so on through a family tree. Thus the child of a father who resembled his own father's family may inherit a resemblance to his paternal grandfather, but cannot inherit resemblance to his paternal grandmother's line.

Thus at its very outset, thanks to the talent of an early Greek philosopher, speculation regarding genetic phenomena was much closer to our contemporary notions than geneticists unaware of this early history of their subject could suppose.

Unfortunately, the western Greek medical tradition, while retaining the notion that heredity is transitive, did not adopt the doctrine that traits are discrete and inherited on an

either-or basis. In the eastern medical tradition, this discreteness of hereditary traits was recognized, but in a form which eliminated their transitivity. In their philosophic doctrines, where considerations of genetic theory appear that had a decisive historical importance, Plato seems to have followed the western medical tradition, and Aristotle a modified version of the eastern tradition.

Sources and Notes

1. pseudo-Hippocrates, *On Diet,* ii.23; R. G. Bury, *The Symposium of Plato,* xxxii-xxxiii.

2. An exception to the general reaction of poets is W. E. Leonard, whose metrical translation of *The Fragments of Empedocles* is poetic and sympathetic. The fragments are given in Greek in Leonard's translation; also, in German and Greek, in H. Diels, *Fragmente der Vorsokratiker,* 3rd edition, I, 193-283, and in English prose in Kathleen Fuller, *The Pre-Socratic Philosophers.* A coin issue of the city of Selinus commemorating a public-health project directed by Empedocles is described in B. V. Head, *Historia Numorum,* p. 168.

3. Censorinus, *De Die Natali,* [238 A.D.], 5,4; quoted in Diels, *op. cit.,* I, 215-16: ex dextris partibus profuso semine mares gigni, at e laevis feminas Anaxagoras Empedoclesque consentiunt. quorum opiniones, ut de haec specie congruae, ita de similitudine liberorum dispariles; super qua re Empedoclis, disputata rationes, talis profertur. si par calor in parentum seminibus fuit, patri similem marem procreari; si frigus, feminam matri similem. quodsi patris calidius erit et frigidius matris, puerum fore qui matris vultus repraesentet; at si calidius matris, patris autem fuerit frigidius, puellam futuram quae patris reddat similitudinem.

4. Aristotle, *De Generatione Animalium,* 746a 1; Diels, *op. cit.,* 215-16.

5. Cf. Parmenides, [fl. 475 B.C.] fragment 17, Diels, *op. cit.* I, 163; Burnet, *Early Greek Philosophy,* 5th ed., p. 178.

6. This Pythagorean-Crotonian position is echoed by Plato, and one of its genetic diagrams preserved by Plutarch, *De Iside et Osiride* 56, p. 373F; translated and discussed by Sir Thomas Heath in *The Thirteen Books of Euclid's Elements,* 2nd edition, pp. 417-18.

7. Note that the compression of Censorinus' statement may quite possibly echo the terseness of his original.

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DAIRY COW HAS PARTURITIONS THREE WEEKS APART*

EVEN though the dairy cow usually produces only one offspring at a birth, twins are moderately frequent. Pfau *et al.*[3] reported 3.95 percent twinning in a Holstein herd over a period of fifteen years. Lush,[2] in a study of the hereditary aspect of twinning, reported as high as 8.8 percent twinning in individual herds.

Several studies have found that twin gestations are generally of shorter duration than the gestations of single births.[1,3] It has also been reported that the condition of retained placentae was very much aggravated by the occurrence of twinning.[3] However, it is rather unusual for normal twins to be born more than a few days apart.

A case of a grade Holstein cow that reportedly gave birth to two normal calves 23 days apart was investigated by the writers. This cow, eartag number L228197, owned by the District Training School, Laurel, Maryland was bred artifically to the Holstein bull, S. J. C. Valley Emperor Star 857269, by a technician of the Maryland Artificial Breeding Cooperative on August 6, 1947. Twenty-two days later on August 28, 1947, the Herdsman observed this cow again showing external signs of estrus and reported her to the technician for a second service. Semen from the same Holstein bull was available for this second breeding, as collections are generally made once each week from the bulls in the stud.

On May 14, 1948, cow number L228197 dropped a normal heifer calf. As this calving followed the service of August 6, 1947, by a gestation period of 282 days, the Herdsman assumed that the cow had conceived from this service and that the signs of estrus observed at the time of the second breeding were due to a "false heat." The passing of a placenta was observed, and on the seventh day following parturition milk production was up to 48 pounds per day.

However, on June 6, 1948, the Herdsman reported that cow number L228197 had dropped a second normal heifer calf, and that another placenta had then passed. This second parturition followed the second service by 282 days and the first service by 305 days.

Blood Types

Blood types of the four animals concerned were made by Dr. Clyde Stormont, Depart-

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