Origins of Genetic Determinism in Medieval Creationism

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Abstract:
The discovery of statistical laws of heredity by Gregor Mendel was an important advance in biological science. However, Mendel's opinion that the entire character was transmitted was not derived from his data and instead reflected prior beliefs outside the domain of science. It is argued here that Mendel, a monk and later abbot of an Augustine monastery, was influenced by St. Augustine's theory of divine creation of the rationes seminales which specified the form for all future beings in great detail. Furthermore, the continued adherence to genetic determinism among contemporary scientists is largely, despite strong evidence supporting a developmental systems or dialectical view of heredity and development.
Keywords: St. Augustine, Mendel, Bateson, heredity, epigenesis, dialectics, reductionism

Article:
On the occasion of the centenary of Mendel's famous paper on hybrid crosses of garden peas, Oliver (1967) distinguished between the forefathers and modern practitioners of genetics: "Early Mendelists supposed that there was regularly a one-to-one relationship between genetic factors and their associated characters. Each character was thought to be determined by a corresponding pair of genes. This conclusion developed into a dogma, which had to be abandoned later." The dogma in question is the purest and most extreme form of genetic determinism. It asserts that important characteristics of the adult organism are specified at conception and appear inevitably, despite buffeting by an ever-changing environment. In politics today, a slightly altered version of this doctrine (e.g., Herrnstein & Murray, 1994) is sometimes invoked as an argument against measures to aid those suffering poverty and oppression (see Rose et al., 1984; Wahlsten, 1997).

Contrary to Oliver, however, it is argued here that Mendel himself was influenced by an ancient form of this dogma permeating European society for centuries prior to Mendel, and that many scientists working on heredity after Mendel who embraced the dogma did not learn the catechism from him, although they were undoubtedly influenced by Mendel's experiments. So pervasive is the influence of this ideology today that many scientists, while often unaware of its origins, have not yet abandoned it. Indeed, Strohman (1997) observes that in the era of molecular biology, ".. the consensus around genetic determinism is extremely well developed and powerful" and the gene is frequently seen "as ultimate control agent."

My concern is not with the concept that discrete units we call genes are important for heredity. The reality of the gene is well established and vast knowledge about its structure and chemistry now exists. The relation between genes in the one-celled embryo and development of adult characteristics, on the other hand, is very much disputed. Modern genetic determinism claims that the DNA molecule contains a blueprint or code for adult structure and behavior or a program for the steps in brain development This doctrine is essentially the same as the belief that an entire character is itself inherited and need only grow through enlargement, a belief once enshrined in the preformed homunculus (see Gould 1985; Jacob 1976). An alternative opinion about heredity and development first arose as the doctrine of epigenesis in embryology and today is expressed by a variety of theories of complex living systems (Ford & Lerner 1992; Gottlieb 1992; Levins & Lewontin 1985).

Mendel

The notion that the character itself is transmitted from parent to offspring was clearly apparent in Mendel's 1865 paper (see Mendel 1970), although at the end of the paper he speculated there might be more to the story. Sturtevant (1967) remarked: "I have found no clear distinction in his paper between the character as such and the hereditary element responsible for it." For Mendel, the laws of transgenerational heredity were the focus and development of the characters in the individual was not a concern. He carefully chose 22 varieties of pea plants after a preliminary trial lasting two years, and he studied these in pairs that showed "constant differentiating characters" such as round versus wrinkled seeds, green versus yellow endosperm, long versus short stem. Seven such characters were chosen for analysis. By "constant," Mendel meant that in his carefully controlled garden plot the variety bred true for its form of the character and all plants of one variety showed virtually the same outcome of development, generation after generation. Characteristics showing greater variability were deliberately not chosen for the experiments.

The first experiment involved cross-pollination of two varieties having different characters. Mendel observed: ".. the common characters are transmitted unchanged to the hybrids and their progeny, but each pair of differentiating characters, on the other hand, unite in the hybrid to form a new character.." (p. 338 in the English translation reprinted by Bateson, 1913). Invariably one character was dominant over the other in the hybrid, e.g. round crossed with wrinkled yielded round and never wrinkled. Crossing the hybrids led to the reappearance of the recessive character. Mendel claimed: "...those characters which are transmitted quite, or almost unchanged in the hybridization, and therefore in themselves constitute the character of the hybrid, are termed the dominant, and those which become latent in the process recessive. Crossing these hybrids, the "hybrids form seeds having one or the other of the two differentiating characters.."

At the end of his paper, Mendel embraced the cytological theory that one pollen cell and one egg cell unite to form a one cell embryo, and he averred that his laws of heredity are "founded on the material composition and arrangement of the elements which meet in the cell in a vilifying union". In the hybrid, "we must then assume that between those elements of both cells, which determine opposite characters, some sort of compromise is effected." Although he appeared to move away from the idea that characters themselves are transmitted, nevertheless genetic determinism was proclaimed: "The differentiating characters of two plants can finally, however, only depend upon differences in the composition and grouping of the elements which exist in the foundation-cells .."

To some extent, Mendel appreciated the role of environment and the process of development. He sought to control the environment in order to perceive the laws of heredity more clearly. Discussing the flowering time of peas plants, he emphasized that seeds must be sown at the same depth and temperature variations must be taken into account to obtain definitive results, which he had not achieved, and therefore he decided not to study flowering time. Concerning the length of stems, he noted this would breed true only with "healthy plants, grown in the same soil,." emphasis added] When studying long versus short stems, he transferred those with short stems to a special bed to prevent them being overshadowed and deprived of sunlight by taller siblings. This could be done by noticing the "compact growth and thick dark-green foliage" in the young plant destined to become an adult dwarf. Further concerning development: "It is almost superfluous to mention that the pods must remain on the plants until they are thoroughly ripened and have become dried, since it is only then that the shape and colour of the seed are fully developed."

It appears that the doting Mendel carefully observed and cultivated his plants in order to obtain the desired differentiation of characters. In one sense this was brilliant research because his careful attention to so many details laid bare the laws of inheritance that today carry his name. At the same time, his experiments were not intended to study the process of development and in fact provided virtually no information about how the adult forms were achieved. Mendel did not demonstrate that the difference in characters would be the same in all environments; instead, he studied the outcome of development in only one uniform garden plot. He appeared to presume the distributions of character types would be the same in any other environment, and he was confident that results with his seven chosen characters fully justified "the acceptance of the principle that a similar relation exists in the other characters which appear less sharply defined.."

Bateson

After Mendel's discoveries were verified in plants in 1900 by three other investigators, William Bateson became a foremost exponent of Mendelism and compiled evidence from numerous species that supported the generality of Mendel's findings about ratios in hybrid crosses. Bateson coined the term "character-unit" or "factor" to represent the thing that was transmitted from parent to offspring, emphasizing that the "characters behave as units." Carlson (1966) commented: "Although Mendel was not consistent in keeping these two concepts separate, he did not merge the two, as Bateson did. In this hyphenated form, the unit-character conveyed the impression that the character, and not some `formative element' or unit, was inherited."

As more studies of diverse characters in a wider range of circumstances were executed, it became apparent that things were not quite so simple, however. Bateson (1913) noted that there sometimes ".. are intermediates due to the disturbing effects of many small causes not of genetic but presumably of environmental origin." (p. 239, emphasis added). Within genetically pure lines of plants produced by inbreeding, fluctuations in weight of seeds "are due to interference which is external, or environmental in the wide sense.." (p. 240, emphasis added). The choice of wording is important, because it implies that the hereditary unit codes for a specific outcome of development, and environments can only disturb or interfere with the internally predestined result.

Bateson acknowledged that, especially in humans, the consequence of inhering a character-unit or factor may not always be inevitable: "It is not in dispute that the appearance or non-appearance of a characteristic may be in part decided by environmental influences. Opportunity given may decide that a character manifests itself which without opportunity must have lain dormant." For him, the character was fully specified in the hereditary units and environment played only an enabling role. Concerning the units, he wrote: "They are the fundamental elements, and consequences of environmental interferences are subordinate to them." (p. 303, emphasis added) This kind of genetic determinism is widespread among scientists even today. Mendel, Bateson, and their followers believed the hereditary unit is the fundamental determinant of form, whereas environment disturbs, perturbs and interferes with the pure type the gene is designed to produce in the adult. Instead of the internal and external factors being equally important and inseparable co-determinants of development (e.g., Gottlieb 1992), the internal factor is seen as having causal precedence and specifying form (see critique by Oyama, 1985). A reaffirmation of this doctrine was made more recently by Scarr and McCartney (1983:424): "..genotypes must be the source of new structures.... In development, new adaptations or structures cannot arise out of experience per se."

It is important to recognize that all the opinions of Mendel and Bateson concerning the role of heredity in development were not substantiated by the data from experiments. They manipulated heredity by inbreeding and cross-breeding while holding environment nearly constant. What they demonstrated, with truly remarkable clarity in the case of Mendel, was that a difference in heredity could cause a difference in the outcome of development. They then went beyond the facts to presume that the elements present at conception determine or, in more modern parlance, code or program for the adult character. While deliberately varying only heredity and noting the characteristics only of adult organisms, they expressed opinions about the intervening process of development that had not yet been examined thoroughly in research.

Many of our contemporaries make this same mistake. Observing that a mutation in a gene can lead to bizarre behavior and malformation of the mouse cerebellum (e.g the reeler, staggerer or Lurcher mutations), they sometimes conclude that the gene in question codes for the structure of the cerebellum. Since the early days of genetics, it has been customary to name a gene for its most salient effect in the adult. Thus, mutations leading to syndromes of obesity and diabetes in mice were named obese and diabetic, and a gene causing poor memory for odors in fruit flies was named dunce. In humans, many mutations known to cause disorders such as phenylketonuria (PKU) and Huntington's disease were named for the syndrome. Although this is recognized by many sophisticated scientists as merely a convention for naming a gene whose mechanisms of action are unknown, the practice implies to many others that the genetic molecule codes for its consequences at the neural or behavioral level. This belief endures and spreads despite abundant evidence that the gene codes only for the structure of a protein molecule and does not code for any part of the brain or any specific behavior. Conventions for naming genes are thankfully being modified. Now, when the protein for which the gene codes is discovered, the gene is properly renamed according to the protein. The metabolic disorder PKU is caused by a defect in the gene coding for the liver enzyme phenyalanine hydroxylase (PAH), and the gene has been renamed as the PAH gene, a mutant form of which will cause PKU unless the child is treated with a special diet. However, this convention does not overcome the determinist implication entirely. For example, the obese gene in mice codes for a protein recently discovered and named leptin, and the obese mutation is now referred to as an "allele" or alternate form of the leptin gene (lep(ob)). Leptos is a Greek word meaning thin, and the implication remains that the gene codes for thinness, whereas its mutant form codes for fatness.

Terminology often conveys meaning that goes well beyond the technical use of a phrase, especially when the words are taken directly from common language. Certain concepts utilized in genetics today entail the genetic determinist theory espoused by Bateson and other founders of this field. Because the observed character often does not correspond uniquely with the genes, special terms have been devised to describe departures from the Mendelian ideal. When a homozygous recessive genotype sometimes but not always causes an aberration of development and many individuals with that genotype appear normal, this is known as incomplete penetrance. For example, less than half of the mice in the highly inbred BALB/c strain suffer total absence of the corpus callosum that normally unites the cerebral hemispheres (Wahlsten, 1989).

On the other hand, a one-to-one correspondence between genotype and is said to reveal a completely penetrant genotype. The obvious implication here is that the genotype codes for the character in question, but in some cases this intended result of the genes goes awry and the genetic message does not penetrate to the level of observable character. A closely related phenomenon occurs when all individuals with a mutant genotype are clearly abnormal but there is nevertheless great quantitative variability among their measured characters, as occurs with the shaker short-tail allele of the dreher gene in mice (Wahlsten 1983).

Qualitatively, the genotype is said to be completely penetrant, but there is variable expressivity. That is, the genotype does not express itself uniformly at the level of character. If, on the other hand, the result is uniform, no special term is used to designate this outcome that is expected from Mendelian theory. Thus, if there is an imperfect correspondence between genotype and character, special terminology is employed to label the exceptions, and these terms imply the Mendel-Bateson theory that the hereditary element or factor is destined to produce a specific outcome of development but its effects are thwarted or destabilized by some extraneous influence. The examples cited are taken from my own research in order to make a point. Although I and many others in behavioral and neural genetics do not agree with the concept of a gene coding for a specific character, we are bound by convention to employ a terminology that originates in genetic determinism. This seemingly innocuous practice makes it more difficult for me, my students, and colleagues to make a complete break with obsolete theory

Woltereck, Johannsen and Morgan

The science of genetics attracted numerous researchers after 1900, and its further development was not at all in a straight line towards a monolithic theory. Many aspects of heredity were and still are hotly debated. Morgan (1910) observed that the "literature of development and heredity is permeated through and through by two contending or contrasting views...One school looks upon the egg and sperm as containing samples or particles of all the characters of the species, race, line, or even of the individual...The other school interprets the egg or sperm as a kind of material capable of progressing in definite ways as it passes through a series of stages that we call its development.". Morgan referred to the view that each character of the adult is represented by a part of the embryo as "modern preformationism."

Johannsen (1911) contrasted the "transmission-conception" of heredity with the "genotype-conception" and became a champion of the latter. The transmission conception sees a more or less direct transmission of personal qualities from parent to offspring, and Johannsen considered this opinion to be naïve and superficial, He was the first to draw a clear distinction between the genotype of the individual as the sum total of its genes, and the phenotype that is a measurable characteristic. Genes are transmitted but phenotypes develop, and many phenotypes are possible for any particular genotype. Characters are not transmitted and genes are not intended to produce any particular phenotype. Of utmost importance was Johannsen's recognition that the development of an individual depended jointly on its genotype and environment. He cited the work of Woltereck (1909) on the growth of water fleas under different levels of nutrition and supported Woltereck's concept of the "Reaktionsnorm," the "sum total of the potentialities of the zygotes.." (norm of reaction; see Platt & Sanislow, 1988). Woltereck found that the curves relating head size to nutrition had different shapes for different strains of Daphnia (see Woltereck's figure in Wahlsten & Gottlieb, 1997). Johannsen saw this and other evidence as support for his belief that ".. the particular organism is a whole, and its multiple varying reactions are determined by its `genotype' interfering with the totality of all incident factors, may it be external or internal".

The group led by T. H. Morgan conducted elaborate experiments with the fruit fly Drosophila and made this a favorite model organism for genetic analysis. By making detailed observations of numerous phenotypes of flies from various crosses, they correctly inferred that some genes tend to be inherited together because they are located near each other (linked) on the same chromosome, and they constructed chromosome maps showing the relative locations of dozens of genes of their humble subjects. Morgan had been trained in embryology (Allen 1983), and his early view of hereditary factors marked an important departure from the determinist tradition of Mendel: ".. a factor, as I conceive it, is some minute particle of a chromosome whose presence in the cell influences the physiological processes that go on in the cell. Such a factor is supposed to be one element only in producing characters of the body. All the rest of the cell or much of it (including the inherited cytoplasm) may take part in producing the characters...A single factor may affect all parts of the body visibly .." (Morgan 1914)

The use of language here is significant. Instead of a factor or gene determining a character, the gene influences processes inside a cell. It participates in the development of a wide array of phenotypes, a concept now known as pleiotropy. Furthermore, the chromosomes are not the sum total of heredity; instead, the cytoplasm, which is inherited only via the egg and not according to Mendel's laws, is an integral part of heredity. Experiments involving two or more genes studied simultaneously led to the discovery of many instances where the genotype at one locus dramatically influenced the effects of genotype at another locus. This kind of gene-gene or epistatic interaction demonstrated clearly that the gene is a molecule that functions in the context of other molecules, and the outcome of development is a complex product of many interacting influences. (Morgan himself later drifted towards a more reductionistic, gene centered perspective. See Allen 1983.)

Developmental systems theory

Decades of genetic investigations with diverse organisms led many theorists to a view known as developmental systems theory (Ford & Lerner 1992; Gottlieb et al. 1997), or dialectical biology (Levins & Lewontin 1985). In this view, the gene is an integral part of a complex metabolic system of a cell and it codes only for the linear structure of a specific protein molecule. The cellular consequences of that protein depend on thousands of different proteins and other molecules present in the cell, and the role of the cell in development depends on nearby cells that interact with it. The developmental trajectory of the entire individual depends on its environmental context. The action of a gene, when and where it is turned on to synthesize its protein, is governed by events external to the gene, including in many cases the external environment of the organism. A mutation of a specific gene can radically alter the course of individual development, but this does not mean that the mutant form of the gene codes for the specific outcome of development. On the contrary, a mutation often renders the organism more sensitive to external perturbations and less capable of regulating its internal milieu in the presence of a variable environment. Likewise, the normal, viable form of the gene does not code for any specific outcome or character; its effects are contingent and relative, not preordained. This systems view of heredity originated in the 19(th) century and was further elaborated as knowledge of genetics, molecular biology, and developmental psychology accumulated in the 20th century.

However, the systems view is not universally understood, appreciated, and embraced today. Genetic determinism is very much alive and perhaps even the dominant view (Strohman 1997). Thus, two major questions need to be addressed if we are to comprehend the origins of genetic determinism. The first concerns the historical origins of the opinions of Mendel, Bateson and theorists of like mind who believe inherited elements, factors or genes directly specify the character or phenotype, even though experimental proof of this view is lacking. The second concerns the continued adherence to this strongly reductionistic perspective, despite growing evidence against it.

Augustine and Thomas Aquinas

The history of an idea is a subject of immense difficulty, and an acceptable account must be more complex than even the labyrinthine paths to knowledge of sophisticated thinkers like Mendel and Bateson. A biographical study of Mendel (Orel 1984; see also Sturtevant 1965) tells us much about his education in physics, mathematics, chemistry and biology at the University of Vienna, his enthusiastic participation in scientific societies in Moravia, and his involvement in the politics of the Austro-Hungarian empire. This approach to understanding the man highlights his strengths in science and helps to explain his most noteworthy achievement - the discovery of statistical laws of heredity. Unfortunately, it offers little insight into the sources of his erroneous opinions concerning the deterministic development of organisms.

Orel (1984) attributed Mendel's reductionism to his training in the analytical met of physics and chemistry. These sciences do employ analysis of a thing into its component parts, but this is more akin to what Gottlieb et al. (1997) refer to as methodological reductionism, a tool that most of ns use in our research. Physics and chemistry are not wedded to theoretical reductionism, however, these disciplines do not attribute properties of a whole thing to a simple sum of its parts. Instead, they emphasize interactions among the parts, as with Newtonian gravitation or the theory of the chemical bond. There must be more to the views of Mendel and his followers than the doctrines of cognate sciences.

One aspect of Mendel's life is mentioned in most biographies but then treated as a remote and uninteresting feature. Mendel came from a family of little wealth and was able to continue his education and attain financial security to conduct scientific research by becoming a monk in the Augustinian monastery in Brno (Orel 1984). He was elected abbot three years after publishing his famous paper on hybrid peas, and not long before his death in 1884 he had a painting commissioned for the abbey ceiling with St. Augustine in the center of four disciplines of science. This inspires me to inquire into Augustine's views of heredity, where we find a clear doctrine of biological determinism contained in an elaborate theory of creation. Mendel must have been aware of this doctrine before he embarked on his studies of heredity. Hence, the remarkable similarity of Augustine's theory and Mendel's view of development warrants attention. I propose that the Medieval doctrine of creationism was an important influence on Mendel's thought and the thinking of many of his contemporaries and successors. This is more than plausible. Kalmus (1983) has documented scholastic and Aristotelean influences on Mendel's thought, and he established that Mendel studied Latin and had access to writings of Augustine and Thomas Aquinas. He also claimed that the ideas of these two Saints "were certainly taught to Mendel." Morgan (1919) asserted "an historical connection between the medi…val theory of preformation and the particulate theory of heredity."

Augustine became Bishop of Hippo Regius, near the ancient site of Carthage in what is now Tunisia. He lived in the period of the decline of the Roman empire, which was marked by the sack of Rome by the Visigoths in 410, and he died during a Vandal siege of Hippo in 430 (Battenhouse 1955). His numerous writings on theology were later interpreted and extended by Thomas Aquinas (1225-1274), a Dominican priest from a wealthy Italian family who was a champion of Aristotle as well as Augustine.

Augustine was strongly influenced by Plato, whom he credited with "brilliance," and Neo-Platonic philosophy but apparently lacked exposure to the biological works of Aristotle. Neither Augustine nor Thomas Aquinas undertook scientific studies as we now think of science, and they relied heavily on ancient texts for authority, as was typical through much of the Medieval period. Discussing the age of the earth, Augustine supported the estimate of Eusebius of 5,611 years between creation of the earth and the sack of Rome rather than a figure of 8,000 years proposed by an Egyptian priest, because the calculation by Eusebius "does not exceed the true account of the duration of the world as it is given by our documents, which are truly sacred." (City of God, Book XII, Chap. 10). Likewise, Thomas Aquinas asserted: "The articles of faith cannot be proved demonstratively .. But that God is the Creator of the world; hence that the world began, is an article of faith .. [The] newness of the world is known only by revelation...[It] cannot be demonstrated from the world itself." (Summa Theologica, Part I, Q. 46, Art. 2)

Nevertheless, both men struggled to understand what was written in the Bible in terms of the knowledge of the world they possessed. Augustine devoted considerable attention to the story of creation in Genesis and sought to reconcile this with generally accepted beliefs about his world. These beliefs included spontaneous generation of living organisms from non-living matter and the deeds of magicians who could apparently produce animals at will. There were also stories of miracles in the Bible, such as feeding thousands of people with a few fish or turning water into wine, that were widely believed. Other theorists, considered heretics by Augustine, argued that these were instances of continuing creation and the frequent involvement of God in human affairs.

Augustine wrote three commentaries specifically on Genesis in which, according to a leading Jesuit scholar, he "searched with increasing anxiety for the scientific explanation of the beginning of things." (Portalié 1960) The most complete and latest (401 to 415) was the Literal Commentary on Genesis, a work written in Latin (De Genesi ad Litteram) and recently translated into French (Augustin, 1972) but not English. For Portalié (1960), "His purpose was to settle in proper manner any disagreement between the biblical account and true science." Portions of his theory are available in English in his major works (The Trinity, The City of God), and several studies of De Genesi ad Litteram have also been published (especially Bourke 1964; McKeough 1926).

Augustine's theory of creation had five parts, the first two being cosmology and the other three appearing more like biology (Anderson 1965; Christian 1955; Portalié 1960). Although we may see the whole doctrine as theology rather than science, during much of the Medieval period (circa 400-1500) no such distinction was made, and science in its modern form did not begin to emerge in Europe until late in that period (Goldstein 1980; Lindberg 1992).

1 - The entire world was created out of nothing in an instant by God's will. There was only one act of creation and there is no continuing (or special) creation of new matter or forms in the world today.

2 - At the beginning, some things existed actually but others, such as animals, existed only potentially. Matter existed but had no form. Only with the passage of time did animals appear. This portion of the doctrine echoed the Platonic teaching that matter by itself has no spontaneous creative powers. Augustine stated:

"A thing cannot fashion itself, for a thing cannot give itself what it does not have." Action, form and development required a cause separate from bodily substance, which on its own was regarded as passive and formless.

3 - The forms of living things were created at the beginning as infinitesimal specks containing "seeds" for future organisms. These specks were termed the rationes seminales by Augustine, translated later as seminal principles or seeds of creation by scholars. Augustine sated: "From these elements as original principles of things, all things that are generated take their origin and development, each in its proper time, and they receive their terminations and diminutions, each according to its kind. Hence it develops that a bean does not grow from a gram of wheat, or wheat from a bean, or a man from a beast, or a beast from a man." (De Genesi ad Litteram, Book IX, cited by Bourke 1964) The rationes seminales could produce new organisms through the usual sex and reproduction, but they also allowed the possibility that an adult animal could appear suddenly, as was believed to occur in spontaneous generation and miracles. Thomas Aquinas held that "..miracles are not wrought outside the scope of causal principles."

4 - The rationes seminales did not specify solely the type of species of animal; they were believed to contain details of all future individuals. Augustine wrote that "nothing would have been made had it not first been known by Him" and that all things must exist "in the places assigned to them by the order of their nature." Concerning the present state of the world: "For as mothers are pregnant with unborn offspring, so the world itself is pregnant with the causes of unborn beings, which are not created in it except from the highest essence, where nothing is either born or dies.." (The Trinity, Book III, cited by Bourke 1964:83) Asked what form a dead infant would have achieved had it lived, Augustine replied that all things possess a specific form ".. in principle, not in actual bulk. Similarly, all the organs are latent in the seed, even though at birth some have not yet appeared .. On this basis, the infant is already short or tall, if he is going to be short or tall." (City of God, cited by Bourke 1964:132)

Beholding these lines from St. Augustine, the Catholic scholar Bourke remarked: "Aetiologically, the similarity of this Augustinian insight with the modern biological explanation of inherited characteristics in terms of genes is striking. Augustine simply pushes the causal explanation back to the very beginning of the genetic process.."

5.- The rationes seminales existed as plans for future organisms. Augustine made an analogy with human plans: ".. we do not say that Rome and Alexandria were built by masons and architects, but by the kings by whose will, plan and resources they were built.." So it was with the plans for the finished products, adult humans, plants and animals, that Augustine believed were created by an omniscient being thousands of years before they appeared on earth.

After carefully studying this theory that tiny specks provide detailed plans for the parts of each organism, one Catholic scholar commented: "The recently developed science of Genetics has brought forth an explanation of observed facts which has much in common with the ancient theory." (McKeough 1926:27) McKeough took careful note of the writings of Bateson: "Attention must be called here to the most remarkable agreement between the system of St. Augustine and a theory proposed a few years ago by one of the foremost scientists of our day, Dr. Wm. Bateson. In a report on Heredity, read at the Australia meeting of the British Association for the Advancement of Science, he suggests that evolution may be not an accumulation of additional factors, but an unfolding of possibilities contained within the original forms of nature."

Neither McKeough nor Bourke nor any of the other religious authorities I have consulted mentioned, however, that Mendel himself had been steeped in Augustinian theology. Given Mendel's own history and his central position as abbot of an Augustinian monastery, it seems highly likely that he was influenced by this theology. Could it be that, where facts do not clearly point the way, ancient philosophies still hold sway? Data on hybrid crosses of peas led Mendel to proclaim statistical laws of inheritance of "elements" consistently associated with characters of the adult plant His superb experiments revealed these laws with unprecedented clarity, but his observations provided little or no information about how a seed became transformed into an adult plant with its unique array of characters. Lacking definitive data, preconceived ideas filled the void.

It is clear that no conflict occurs between the Augustinian theory of the rationes seminales and the Mendelian conception of particulate heredity or even the more modern doctrine of determination of development by a code in the DNA. In the many debates about science and religion in recent times, the doctrines of Mendelian genetics have not be subjected to attack; on the contrary, some writers have seen supernatural design in the structure of DNA. For example, the geneticist Francis Collins, director of the lavishly funded National Human Genome Research Institute at the National Institutes of Health in the U.S.A. and a committed Christian, recently remarked: "When something new is revealed about the human genome, I experience a feeling of awe at the realization that humanity now knows something only God knew before." (Easterbrook 1997: 892).

The Darwinian theory of evolution, on the other hand, has been a principal target of biblical literalists for many decades (see Numbers, 1992). Augustine was a consistent creationist (Bourke, 1960, 1964; McKeough, 1926; Portalié, 1960), and his theory of the rationes seminales lent itself to a form of special creation, where new species appeared later in the history of the earth only because conditions had then occurred that favored the expression of long dormant seeds specifying the new forms. From a thorough study of Mendel's extant writings, it is apparent that he was a believer in special creation, not Darwinian evolution by descent with modification (Callender 1988).

Several aspects of Augustine's philosophy were not adopted or emphasized by Mendel. Augustine's view of cities as the achievement of a ruler expressed an elitism that extolled the ruling minority and denigrated the palpable achievements of workers who created the material objects of civilization. Mendel, on the other hand, struggled against poverty as a young man and became an advocate of expanded civil rights in a period of revolution (the events of 1848; see Orel 1984). Augustine's theory of "seminal" principles followed the sexist Greek tradition of attributing higher mental processes to males and denying females participation in creative endeavors. Mendel's laws, on the other hand, regarded males and females as inherently equal in the process of reproduction. He was in no way an unthinking sycophant of the ecclesiastical hierarchy of his religious order or a slavish follower of Augustine and Thomas Aquinas. He acquired competence as a scientist and made discoveries of great importance. All this notwithstanding, he imbibed the Augustinian theology, and this assimilated view of creation influenced his own thinking about heredity and development.

Mendel's theory of the inheritance of characters was a decisive refutation of the theory of preformed individuals, the proverbial nested Russian dolls that presumed an end to a finite world (see Gould 1985; Jacob 1976), but it was not opposed to a more broadly construed kind of preformationism, a mosaic theory of heredity. In place of the divine design of future individuals, there was a more refined notion of discrete phenotypes by design, a concept that allowed for a virtual infinitude of whole individuals extending to eternity. Perhaps this idea contradicted the theory of Augustine, but the Saint's ideas were not sacrosanct like the more vaguely and poetically stated book of Genesis. Portalié (1960) noted that Augustine himself expressed dissatisfaction with his answers and hoped to "provoke further inquiry." Mendel made such an inquiry and in effect refined the theory of the rationes seminales, although he never mentioned the term and obviously addressed his discoveries to fellow scientists rather than religious authorities.

Creationism and Modern Science

It is likely that Mendel, as first a novice and then the abbot of an Augustinian monastery, was aware of the philosophy of creation espoused by Augustine and was influenced by this theory when formulating his views of heredity. However, Mendel was merely the first to observe the statistical regularities of phenotypes in hybrid crosses, and many other scientists of diverse philosophies obtained similar results and made similar interpretations (see Bateson 1913). Few, if any, of his followers in this field were avowed Augustinians, and it seems likely that most of them had little or no direct knowledge of Augustine's idea of the rationes seminales. How, then, could this theology exert a more pervasive influence beyond the cloister?

First, it must be acknowledged that Augustine was a dominant figure for centuries among intellectuals in Europe and until quite recently was required reading for most scholars seeking advanced education. Bourke (1960) maintains that "Contemporary scholarship continues to rank Augustine among the great minds of Western civilization.... It is probably impossible to exaggerate the influence of his life and thought." According to Williams (1955): "It was he who in the fourth century [sic] gave to Western civilization the formative ideas which have guided it for centuries." During the rise of universities at the end of the Medieval period, centers of learning at Chartres and Oxford were "saturated with Augustinian philosophy" in relation to the physical world and mathematics as well as theology (Williams 1955; see also Lindberg 1992). It is reasonable to suppose that many learned scholars, while not being devotees of Augustine, gained familiarity with his opinions. Although the writers of modern textbooks may know little of Augustinian views on creation, it seems certain that their teachers or more remote intellectual ancestors did. The Mendelian laws of heredity did not cause them to surrender their lingering views of divine creation. On the contrary, as noted by McKeough (1926) and Bourke (1964), these laws could be viewed as vindication of Augustine's speculation.

Second, natural science and theology have developed in close association for centuries (Shapin 1996) and continue to do so. Science as we know it did not burst upon the scene unannounced and sweep all ancient conceptions away with one grand stroke. Theology continues to have a major impact on the kinds of questions considered worthy of study by scientists, and the purportedly objective findings of science are frequently cited in support of the veracity of religions tenets. Whether the world arrived at its present state by divine creation of a finite universe or evolution of an infinite universe has been and continues to be a question of importance to many intellectuals (Numbers 1992). It would be fatuous indeed to imagine that religious convictions were purged from the minds of scientists in the 20(th) century after the theories of evolution and relativity earned almost universal adherence among scientists. About 40% of research scientists in the U.S.A. profess deist beliefs (Larson & Witham 1997). Many others who now adopt a more consistent materialism were raised from a young age in a religious tradition, years before they were exposed to formal scientific ideas. Given the many heated debates in the media and legislatures about teaching of evolution and creationism in the public schools, it is difficult to imagine a modern biologist or psychologist who has not been compelled to think about this issue. In learned publications the total separation of natural science and theology is almost sacrosanct. Nevertheless, private opinions can intrude into public writings of scientists, even though the source may not be acknowledged.

It is commonly believed that the world as we know it is meant to be this way - that some people should be more powerful and wealthy than others, that men should have greater privileges than women, that Europeans should dominate and rule over people of African ancestry. The doctrine of creation of the world by a supernatural being is sometimes invoked to justify the existing state of affairs. In this context, genetic determinism appears to be a corollary of creationism. It asserts that certain molecules present in the zygote are meant or designed to generate specific characteristics of the individual, that they code for a phenotype. In this respect, genetic determinism is to developmental neuroscience and psychology as creationism is to history.

Although the influence of creationist ideology is ecumenical in modern society, it is often subtle and never universal. Every word that a person reads is understood in the context of years of historically conditioned individual experience and contemplation. Mere exposure to the writings of St. Augustine or his followers does not dictate or explain anyone's thinking. The erudite and eminent physiologist Sherrington (1941), writing about the doctrine of spontaneous generation, demonstrated his awareness of the theory of the rationes seminales asserted by the "patristic authority" of Augustine of Hippo. Sherrington knew it but was not of it. Criticizing the 20th century doctrine of entelechy, whereby genes are said to specify form, he observed: "With that we have a retrogression to mediaevalism."

Bibliography

Allen, GE. (1983). "T. H. Morgan and the Influence of Mechanistic Materialism on the Development of the Gene Concept 1910-1940." American Zoologist 23:829-843.
Anderson J.F. (1965). St. Augustine and Being. A Metaphysical Essay. The Hague: Martinus Nijhoff.
Augustin, St. (1972). La Genèse au Sens Littéral. Translated by P. Agaësse & A. Solignac. Desclée de Brouwer. (Includes the original Latin text of De Genesi ad Litteratum.)
Augustine, St. (1952). The City of God. Vol. 18 of Great Books of the Western World. Chicago: Encyclopedia Britannica.
Bateson, W. (1913). Mendel's Principles of Heredity. Cambridge: Cambridge University Press.
Battenhouse, RW. (1955). "The Life of St. Augustine." Pp. 15-56. in A Companion to the Study of St. Augustine, edited by R.W. Battenhouse. NY: Oxford University Press.
Bourke, VJ. (1960). "Introduction," in A Guide to the Thought of Saint Augustine by E. Portalié. London: Burns & Oates. Pp. xxi-xxxvii.
Bourke, VJ. (1964). Augustine's View of Reality. Villanova, Pennsylvania: Villanova Press.
Bowler, PJ. (1989). The Mendelian Revolution. The Emergence of Hereditarian Concepts in Modern Science and Society. Baltimore: Johns Hopkins University Press.
Callender, LA. (1988). "Gregor Mendel: An Opponent of Descent with Modification." History of Science 26:41-75.
Carlson, EA. (1966). The Gene: A Critical History. Philadelphia: W.B. Saunders.
Christian, WA. (1955). "The Creation of the World." Pp. 315-342. in A Companion to the Study of St. Augustine, edited by R.W. Battenhouse. NY: Oxford University Press.

Easterbrook, G. (1997). "Science and God: A Warming Trend?" Science 277: 890-893.
Ford, DH. & RM. Lerner. (1992). Developmental Systems Theory. An Integrative Approach. Newbury Park, New Jersey: Sage.
Goldstein, T. (1980). Dawn of Modern Science. Boston: Houghton Mifflin.
Gottlieb, G. (1992). Individual Development and Evolution. The Genesis of Novel Behavior. NY: Oxford University Press.
Gottlieb, G., Wahlsten, D. &. Lickliter. R. (1998). "The Significance of Biology for Human Development: A Developmental Psychobiological Systems View," in Handbook of Child Psychology, Vol. 1, Theory, 3(rd) edition, edited by R.M. Lerner. NY: Wiley, in press.
Gould, SJ. (1985). The Flamingo's Smile. Reflections in Natural History. NY: Norton.
Herrnstein, R.J. & Murray, C. (1994). The Bell Curve. Intelligence and Class Structure in American Life. NY: The Free Press.
Jacob. F. (1976). The Logic of Life. A History of Heredity. NY: Vintage Books.
Johannsen, W. (1911). "The Genotype Conception of Heredity." American Naturalist 45:129-159.
Kalmus, H. (1983). "The Scholastic Origins of Mendel's Concepts." History of Science 21:61-83.
Larson, E.J. & Witham, L. (1997). "Scientists Are Still Keeping the Faith." Nature 386:435-436.
Levins, R. & Lewontin, R. (1985). The Dialectical Biologist. Cambridge, Massachusetts:Harvard University Press.
Lindberg, DC. (1992).The Beginnings of Western Science. Chicago: University of Chicago Press.
McKeough, MJ. (1926). The Meaning of the Rationes Seminales in St. Augustine. Ph.D. dissertation, Catholic University of America, Washington, D.C.
Mendel, G. (1970). Versuche über Pflanzenhybriden. Braunschweig: Friedrich Vieweg & Sohn. (Reprints of several of Mendel's papers in German).
Morgan, TH. (1910). "Chromosomes and Heredity." American Naturalist 44:449-496.
Morgan, TH. (1914.) "The Mechanism of Heredity as Indicated by the Inheritance of Linked Characters." Popular Science Monthly January, pp. 1 - 16.
Morgan, TH. (1919). The Physical Basis of Heredity. Philadelphia: Lippineott.
Numbers, RL. (1992). The Creationists. The Evolution of Scientific Creationism. Berkeley: University of California Press.
Oliver, CP. (1967). "Dogma and the Early Development of Genetics." Pp. 3-10. in Heritage from Mendel, edited by R.A. Brink & E.D. Styles. Madison, Wisconsin: University of Wisconsin Press.
Orel, V. (1984). Mendel. Oxford: Oxford University Press.
Oyama, S. (1985). The Ontogeny of Information. Developmental Systems and Evolution. Cambridge: Cambridge University Press.
Platt, SA. & CA. Sanislow. (1988). "Norm-of-reaction: Definition and Misinterpretation of Animal Research." Journal of Comparative Psychology 102:254-261.
Portalié, E. (1960). A Guide to the Thought of Saint Augustine. London: Burns & Oates.
Rose, S.,. Kamin, LJ,. & Lewontin, RC. (1984).. Not in Our Genes. Biology, Ideology and Human Nature. Middlesex, England: Penguin Books.
Scarr, S. & McCartney K. (1983). "How People Make Their Own Environments: A Theory of Genotype Environment Effects." Child Development 54:424-435.
Shapin, S. (1996). The Scientific Revolution. Chicago: University of Chicago Press.
Sherrington, C. (1941). Man on His Nature. NY: Macmillan.
Strohman, RC. (1997). "The Coming Kuhnian Revolution in Biology." Nature Biotechnology 15:194-200.
Sturtevant, AH. (1965). A History of Genetics. NY: Harper & Row.
Sturtevant, AH. (1967). "Mendel and Gene Theory." Pp. 11-15 in Heritage from Mendel, edited by R.A. Brink & E.D. Styles. Madison, Wisconsin: University of Wisconsin Press.
Thomas Aquinas, St. (1952). Summa Theologies. Vol. 19 of Great Books of the Western World. Chicago: Encyclopedia Britannica.
Wahlsten, D. (1989). "Deficiency of the Corpus Callosum: Incomplete Penetrance and Substrain Differentiation in BALB/c Mice." Journal of Neurogenetics 5:61-76.

Wahlsten, D. (1997). "The Malleability of Intelligence Is Not Constrained by Heritability," in Genes, Intelligence, and Success, edited by B. Devlin, S.E. Fienberg, D.P. Resnick & K. Roeder. NY: Springer, in press.
Wahlsten, D. & Gottlieb, G. (1997). "The Invalid Separation of Effects of Nature and Nurture: Lessons from Animal Experimentation." Pp. 163-192 in Intelligence, Heredity, and Environment, edited by R.J. Sternberg & E.L. Grigorenko. Cambridge: Cambridge University Press.
Wahlsten, D, Lyons JP &. Zagaja, W (1983). "Shaker Short-tail, a Spontaneous Neurological Mutant in the Mouse." Journal of Heredity 74:421-425.
Williams, DD. (1955). "The Significance of St. Augustine Today." Pp. 3-14. in A Companion to the Study of St Augustine, edited by R.W. Battenhouse. NY: Oxford University Press.
Woltereck, R. (1909). "Weitere experimentelle Untersuchungen über das Wesen quantitativer Artunterschieder bei Daphniden." Verhandlungen der Deutschen Zoologischen Gesellschaft 19:110-173.