

Human Genetics and Islam: Scientific and Medical Aspects

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Abstract:

Objective: To relate diverse aspects of genetics and its applications to concepts in the Glorious Qur'an and the ḥadīth.

Study Design: The author compared passages from the Glorious Qur'an and ḥadīth with modern concepts in genetics, such as recessive inheritance, genetic counseling, genetic variation, cytoplasmic inheritance, sex chromosomes, genetics-environment interactions, gender determination, and the hypothesis of "pairing in the universe."

Conclusions: A fresh understanding of Islamic scripture reveals references to principles of genetics that predate contemporary discoveries. This highlights the need for further exploration of possible links between science and religion.

Key words: Qur'an, ḥadīth, genetics, genetic counseling, recessiveness, cytoplasmic inheritance, epigenetics, gender determination.

سُنُّهُمْ آيَاتِنَا فِي الْأَفَاقِ وَفِي أَنْفُسِهِمْ حَتَّىٰ يَتَبَيَّنَ لَهُمْ أَنَّهُ
الْحَقُّ أَوَّلَ مَا يَكْفُرُ بِرَبِّكَ أَنَّهُ عَلَىٰ كُلِّ شَيْءٍ شَهِيدٌ

Soon We will show them Our signs in the (furthest) horizons (of the universe) and their own souls, until it becomes manifest to them that this is the Truth. Is it not enough that your Lord witnesses all things?¹

Introduction

Genetics is the study of genes and the principles and mechanisms of heredity, or the means by which traits are passed from parents to offspring.^{2,3} The scientific field of genetics can help families affected by genetic disorders better understand them and possible strategies to decrease their incidence. From the perspective of the faithful, sci-

ence and religion should be intrinsically compatible. While science attempts to describe the reality and mechanisms of creation, only the Creator, God ﷻ, is the All-Knowing. This paper focuses on the science of genetics and applying it to our lives with an Islamic perspective.

Methodology

The Glorious Qur'an and the reports about the Messenger Muhammad ﷺ (ḥadīth, pl aḥādīth) were screened for useful links to modern genetics. Specifically, the sacred texts were searched for the key words in Table 1. The Glorious Qur'an was scanned by manual reading. Narrations of ḥadīth were searched for the same key terms using the online database at dorar.net and then subsequently verified using the online database at muhaddith.org.

Recessive Inheritance and Genetic Counseling

An allele is an alternative version of a gene that produces a distinguishable phenotypic effect. Mendel worked on peas and coined the terms "dominant"

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and “recessive” traits, which are used to describe alleles. Mendelian laws of heredity are applicable to plants, animals, and humans. Alleles segregate in gametes. Haploid cells, such as an ovum or sperm, contain only one copy of a chromosome pair carrying one allele. Gametes unite during sexual reproduction to produce a diploid zygote (the fertilized egg), which contains two copies of each chromosome and hence the two alleles. In autosomal inheritance, both alleles of a gene have to be recessive to express the recessive phenotype whereas only one dominant allele is sufficient for the expression of a dominant phenotype. This also means that a recessive allele may be masked by a dominant allele in one generation but reappear in a subsequent generation.

In the following *ḥadīth*, the word *ʿirq* seems to approximate this concept.

جاء رجل من بني فزارة إلى النبي فقال إن امرأتي ولدت
غلاماً أسودَ فقال النبي هل لك من إبل؟ قال نعم قال فما
ألوانها قال حمر قال هل فيها من أورك قال إن فيها لورقاً،
قال فأنتى أتاها ذلك قال عسى أن يكون نزعُه عِرْقُ قال
وهذا عسى أن يكون نزعُه عِرْقُ

There came a person to the Prophet ﷺ from Banu Fazara and said: My wife has given birth to a child who is black, whereupon Allah's Apostle ﷺ said: Have you any camels? He said: Yes. He again said: What is this [sic: read their] colour? He said: They are red. He said: Is there a dusky one among them? He said: Yes, there are dusky ones among them[.] He said: How has it come about? He said: It is perhaps the strain (*ʿirq*) to which it has reverted, whereupon he (the Prophet) said: It is perhaps the strain (*ʿirq*) to which he (the child) has reverted.^{4,5}

Islam advocated justice and human rights. It is genetically possible for two parents with lighter complexions to bear a dark-complexioned child. Understanding genetic possibilities could prevent false accusations of paternity and consequent abuse of innocent people, especially women.

Genetic counseling advises patients or relatives at risk of an inherited disorder or a trait of the con-

Table 1. Arabic search terms and their corresponding English translations.

Parents	آباء	Inherit	ورث
Womb	رحم	Deliver	ولد
	بطن الأم	Mates	أكفاء
Male	ذكر	Semen	سائل منوي
Female	أنثى	Mother	أم
		Father	أب

sequences and nature of the disorder or character, the probability of developing or transmitting it, and the options available in order to prevent, avoid, or ameliorate it. This complex process can have diagnostic (the estimation of risk) and supportive aspects.⁶

Prophet Muhammad ﷺ probably had an intuitive understanding that some traits inherited from the parents were apparent in ancestral generations but not in the parents. This concept underlies our current understanding of dominant and recessive inheritance. In the following *ḥadīth*, he recommended that a person should carefully select his or her mate. The word *ʿirq* could mean traits or genes, while the word *dassās* is probably used to designate the behavior of human traits that skip a generation but reappear in the next.

تخيروا لنطفكم فإن العرق دساس

Choose well your mate (for your semen) as (the hidden) traits can reappear.⁷

This *ḥadīth* implies that *ʿirq* or gene is not only implicated in simple traits like skin color as in the first *ḥadīth* but are also implicated in the whole range of hereditary traits including character and disease.

Natural Selection

A verse from the Glorious Qur'an mentions that man is created from an extract, *sulāla*, of a liquid:

ثُمَّ جَعَلْ نَسْلَهُ مِنْ سُلَالَةٍ مِّنْ مَّاءٍ مَّهِينٍ

Then He made his progeny of an extract of water (liquid) held in light estimation.⁸

Furthermore, Prophet Muhammad ﷺ stated in a *hadith* that only part of the seminal fluid participates in the fertilization process.

ما من كل الماء يكون الولد. وإذا أراد الله خلق شيء لم
يمنعه شيء

Not from all the liquid comes the child. And if Allah wants to create something, nothing prevents Him.⁹⁻¹⁰

This *hadith* appears in discussions regarding the permissibility of *'azl* (*coitus interruptus* or withdrawal method), a form of contraception that the ancient Arabs knew. Most commentators understood this passage to mean that not every instance of sexual intercourse results in pregnancy. The alternate meaning of the divisibility of the seminal fluid is also linguistically possible, and recent scientific knowledge adds to this interpretation's probability.

These statements from more than 1,400 years ago were confirmed in the modern era. Only one sperm out of hundreds of millions released during copulation fertilizes the ovum. In fact, the great majority of sperm die during their travel toward the ovum. At the end of this voyage, around 500 sperms reach the ovum. This minority must be the most motile to compete for the penetration of the ovum.

This form of natural selection before fertilization takes place not only with sperms but also with ova. A female has at the beginning of her fetal life about six million primary oocytes, diploid cells containing two sets of chromosomes, many of which degenerate before birth. Approximately, 30,000 primary oocytes remain at birth and then begin to mature after menarche at a frequency of just one or very few per every menstrual cycle. The mature secondary oocytes or ova are haploid cells, containing half the chromosomal number as a result of meiotic division. On average, only 400 mature ova capable of being fertilized develop during a female's lifetime.

As part of the natural selection process, genetic variation is ensured partly due to the wide range of probable chromosomal crossovers and recombinations. For example, the total number of possible combinations of chromosomes present in human gametes is 2^{23} , where 23 is the total number of chromosome pairs or $\sim 8 \times 10^6$ possible combinations. Accordingly, after fertilization of a human ovum by a

sperm, the resulting diploid zygote may be produced theoretically with any of 64 trillion ($2^{23} \times 2^{23}$) possibilities of chromosomal pairings. The possibilities are multiplied due to the randomness of the fertilization process in addition to the process of crossing over.¹¹

Natural selection also continues after conception. Up to 78% of pregnancies may be spontaneously aborted. Half of these occur without the knowledge of the mothers, who think the bleeding resulting from the spontaneous abortion is menstrual blood.¹² The great majority of these early unrecognized miscarriages are due to chromosomal abnormalities, which are mostly due to abnormalities in meiosis in the female. Meiosis begins during the third month of a female's fetal life and continues throughout maturity. As time progresses and the age of the mother increases, meiotic division seemingly becomes disturbed and may produce abnormalities (dysjunction) that result in an abnormal number of chromosomes. If this affects autosomal chromosomes, it results in syndromes such as Down's syndrome (trisomy 21), trisomy 13 or trisomy 18. If it affects sex chromosomes, it results in syndromes such as Turner or Klinefelter. These abnormalities may also come from the father's side as a result of faulty meiotic division during spermatogenesis. These are not correlated with the father's age, as meiosis in males is brief, about 72 hours, compared to years in females.² As a result of all these factors, probably only 1% of acts of sexual intercourse result in a conception leading to a viable offspring, and this represents a significant process of natural selection.

Cytoplasmic Inheritance, Sex Chromosomes and Beneficence to Parents

In Islam, both parents are worthy of beneficence:

وَوَصَّيْنَا الْإِنْسَانَ بِوَالِدَيْهِ حَمَلَتْهُ أُمُّهُ وَهْنًا عَلَىٰ وَهْنٍ وَفِصَالُهُ
فِي عَامَيْنِ أَنِ اشْكُرْ لِي وَلِوَالِدَيْكَ إِلَيَّ الْمَصِيرُ

And We have enjoined man in respect of his parents — his mother bears him with faintings upon faintings and his weaning takes two years — saying: Be grateful to Me and to both your parents; to Me is the eventual coming.¹³

Interestingly, however, the above verse gives moth-

ers priority over fathers. This principle is confirmed in a *ḥadīth* where Muslims are instructed to give their mothers three-fold beneficence, respect and caring as compared to their fathers. This should be, at least partially, a matter of compensation for the intensive care that offspring receive from their mothers. The special elevated rank of mothers is alluded to in the following *ḥadīth*:

سئل رسول الله من أحق الناس بحسن صحابتي قال أمك
قال ثم من قال ثم أمك قال ثم من قال ثم أمك قال ثم من
قال ثم أبوك

A man came to Allah's Apostle and said, "O Allah's Apostle! Who is more entitled to be treated with the best companionship by me?" The Prophet said, "Your mother." The man said, "Who is next?" The Prophet said, "Your mother." The man further said, "Who is next?" The Prophet said, "Your mother." The man asked for the fourth time, "Who is next?" The Prophet said, "Your father"^{14,15}

It is noteworthy that regardless of the offspring's sex, cytoplasmic inheritance is exclusively maternal. Actually, cytoplasm contains exclusively maternally inherited mitochondria, which harbor tiny circular DNA molecules that contain 37 of our genes. The genetic balance is, therefore, in favor of mothers.¹⁶⁻⁷ In addition, this is especially true in male offspring who inherit their long sex chromosome X from their mothers but their short sex chromosome Y from their fathers. The X chromosome is much larger (154,913,754 base pairs versus 57,741,652 base pairs) and contains many more genes (1,846 versus 454) than the Y chromosome. This results in more maternal than paternal genetic participation in our development.

In addition to the extra genetic material, organelles such as mitochondria, mRNA molecules, and other determinants present in the cytoplasm of unfertilized oocytes are transmitted to the zygote. These maternal cytoplasmic determinants play a capital role in the differentiation of zygotic cells into the many differentiated cell types through the expression of the appropriate gene(s) in each type of cell. They also determine the body plan and orientation of the embryo.¹¹

Therefore, in addition to the long period of pregnancy, labor, hard delivery, breast-feeding, and continuous care given, mothers contribute more genetic material to their offspring than fathers. Maternal determinants guide embryos towards appropriate body orientation and differentiation.¹¹ Mothers have an extraordinary rank in Islam due to their contributions to life and society. Perhaps Islam also recognizes their contributions to biology and genetics.

Genetics-Environment Interactions

Genetics is concerned with genes inherited from parents, while environment encompasses all the external factors that influence organisms directly or indirectly. For most human characteristics, including those exhibited during health and disease, genes and environment interact to produce the phenotype.¹⁸⁻⁹ A minority of diseases are caused by a single defective gene, e.g. Huntington disease. However, the majority of diseases are caused by multiple defective genes and environmental components that influence the appearance and severity of those diseases. Examples of such diseases include cancer, heart disease, and diabetes.

Similarly, epigenetic alterations that affect human behavior may result from interactions with the environment.²⁰⁻³ Epigenetic changes do not directly alter nucleotide sequences but may rather affect genomic architecture (chromatin folding and attachment to the nuclear matrix, packaging of DNA around nucleosomes) and appendages (covalent modifications of histone tails by acetylation, methylation, phosphorylation, as well as DNA methylation).¹¹ Cellular epigenetic mosaicism and phenotypic differences are reported in genetically identical twins.²³⁻⁴ Convincing evidence on the effect of environment on genetic expression comes from studies on mice that reported epigenetic alterations through DNA hypomethylation after exposure to Bishphenol-A during early development.²⁴ Childhood abuse has also been shown to result in epigenetic changes in the glucocorticoid receptor, and alteration of genetic expression in the brain was associated with suicide.²²

Human psychology is determined by multiple factors and influences. The environment of the womb, with all its biological, chemical, and physical components, evidently has an important impact on the embryo's developing character.

The Messenger Muhammad ﷺ was reported to have said:

الشقي من شقي في بطن أمه والسعيد من سعد في بطنها

The misfortunate one is who became misfortunate in the womb and the happy is the one who became happy in the womb.²⁵

This text and similar ones have been interpreted to refer to the individual's salvation in paradise or punishment in hell. The phrase *batn ummihi* (womb), when compared with other texts, should be interpreted metaphorically to indicate the time before a person's birth. In any case, it may also support the concept that environmental factors may affect the development, character and traits of the fetus in its mother's womb, and that this may result in the child's happiness and misery in this life. The mentioning of this word, *batn ummihi*, the emphasis Islam places upon the rights of children on their guardians and the lengthy discussions Muslim jurists have had in the topic of the care of minors (*ḥaḍāna*) should cause Muslims, in light of the recent scientific discoveries mentioned above, to strive to improve maternal health care.

Gender Determination

The Qur'an clearly states that both men and women contribute to the creation of offspring:

يَا أَيُّهَا النَّاسُ إِنَّا خَلَقْنَاكُمْ مِّن ذَكَرٍ وَأُنثَىٰ

O you people! surely We have created you from a male and a female.²⁶

Another verse talks about mingled *nutfa* (drops of fluid) as the beginning of human creation, implying the contribution of both male and female fluids.

إِنَّا خَلَقْنَا الْإِنْسَانَ مِن نُّطْقَةٍ أَمْشَاجٍ

We created humans from a drop of mingled fluid.²⁷

These two verses indicate both male and female involvement in the formation of the embryo. However, does the father or the mother determine the gender of the offspring? In an authentic ḥadīth of the Prophet ﷺ, he mentioned a "competition"

between the male seminal fluid and the female reproductive fluid *vis-à-vis* the determination of gender:

ماء الرجل أبيض و ماء المرأة أصفر فإذا اجتمعا فعلا مني

الرجل مني المرأة أذكرا بإذن الله وإذا علا مني المرأة مني

الرجل أننا بإذن الله

The reproductive substance of man is white and that of woman is yellow, and when they have sexual intercourse and the male's substance prevails upon the female's substance, it is a male child that is created by Allah's decree, and when the substance of the female prevails upon the substance contributed by the male, a female child is formed by the decree of Allah.²⁸⁻⁹

Another ḥadīth states:

فإن الرجل إذا غشي المرأة فسبقها ماؤه كان الشبه له وإذا

سبق ماؤها كان الشبه لها

If man's liquid (semen) prevails over the liquid of woman, the child will resemble his father. If the woman's liquid prevails over his liquid, then the child will resemble her.³⁰

Consequently, gender is determined by a necessary interaction between paternal and maternal components. How can this be reconciled with the classical concept that the father determines the gender of the child by contributing the male-determining Y-chromosome to his offspring? The answer to this question could include the favoring of either X- or Y-bearing paternal gametes by the prevailing environmental condition in the woman's reproductive tract. Could the competition referred to in the above *aḥādīth* relate to the difference in the pH of the seminal and vaginal fluids?

The pH of the seminal fluid differs from that of the reproductive secretions of females. A woman's vaginal pH ranges from 4.5 to 4.7 (acidic).³¹ In contrast, the normal pH of semen ranges between 7.2 and 7.8 (alkaline).³² Thus the *aḥādīth* may suggest that the more alkaline medium favors male and the more acidic medium favors female offspring. Genetic studies in fish have reported an effect of pH on gender determination. For example, in broods of

Pelvicachromis fishes (kribensis and relatives), acidic water favors males, and alkaline water favors females.³³⁻⁴ Acidity also favors the development of males in other species of fishes such as *Apistogramma cacatuoides*, *A. geophyra*, *A. hongsloui*, *A. nijsseni*. The discrepancy between the presumed effect of observed pH differences in human reproductive fluids based on the interpretation of these *aḥādīth* and the studied fishes indicate that other factors may influence the role of pH in gender determination or that there are other physical, chemical, or physiological characteristics in the male and female reproductive fluids that favor the formation of one gender of the embryo over the other.

In some fish species, other environmental factors such as temperature, hormones, and social conditions influence gender determination. Extreme environmental treatments can even “override” the genetic basis of sex. Genetically-female *Poecilia reticulata*, for example, will mature as males if raised in extreme temperatures.³⁵⁻⁶ Higher temperatures also are found to favor producing more males. The effects of temperature and pH are, however, not “all-or-none,” i.e., not even high temperature and low pH together will effectively produce 100% males.³⁷ Nevertheless, these observations are interesting and warrant further investigation to determine whether an environmental factor, such as pH or temperature, has a role in determination of the gender of the human fetus.

Compatible with the role of the environment discussed above, recent studies have shown that maternal nutrition influences gender determination of the child. A wide range of nutrients, including potassium, calcium (elements that favor an alkaline environment) and vitamins C, E and B12, enhance begetting of boys in contrast to a low-caloric diet, which enhances begetting of girls.³⁸ Such studies demonstrate, effectively, that women also play a role in the determination of the offspring’s gender. This seems to diverge from the hypothesis in classical genetics that gender determination in humans could be attributed only to the father.

In summary, the previously mentioned sacred verses and *aḥādīth* as well as recent scientific literature can lead us to appropriately conclude that while the father is responsible for genetic determination of the child's gender, the environment of the female genital tract may influence the child’s gender.

Specifically, the physical, chemical, or physiological characteristics of reproductive fluids and the nutrition of the mother may be considered environmental determinants of gender.

Hypothesis of “Pairing in the Universe” in the Glorious Qur’an

Pairing, which is the combination of opposites such as males and females or positive and negative, is a general phenomenon found in nature. The pairing or parity phenomenon is also well known in molecular genetics as in the examples of the double helical structure of DNA and the composition of double stranded RNA molecules.³⁹⁻⁴⁰ The Glorious Qur’an evoked this general phenomenon of pairing in a couple of verses:

سُبْحَانَ الَّذِي خَلَقَ الْأَزْوَاجَ كُلَّهَا مِمَّا تُنْبِتُ الْأَرْضُ وَمِنْ أَنْفُسِهِمْ وَمِمَّا لَا يَعْلَمُونَ

Glory be to Him Who created pairs of all things, of what the earth grows, and of their kind and of what they do not know.⁴¹

وَمِنْ كُلِّ شَيْءٍ خَلَقْنَا زَوْجَيْنِ لَعَلَّكُمْ تَذَكَّرُونَ

And of everything We have created pairs that you may be mindful.⁴²

British physicist Paul Dirac, who discovered that matter was created in pairs, won the Nobel Prize for Physics in 1933. This finding, known as “parity,” revealed the duality known as matter and antimatter. Antimatter bears the opposite characteristics to matter. For instance, contrary to matter, antimatter electrons are positive and protons negative. This fact is expressed as follows: “... every particle has its antiparticle of opposite charge... The uncertainty relation tells us that pair creation and pair annihilation happen in the vacuum at all times, in all places.”⁴³

Conclusions and Perspectives

The linking of texts of the Glorious Qur’an and the Prophetic tradition to recent scientific discoveries is a reflection of the additional meanings Muslim scientists may suggest for these texts. However, it must be emphasized that the Qur’an and the Prophetic tradition are foremost sources for human guidance and not sources of scientific knowledge.

Nevertheless, this paper stresses the need for further investigation of genetic discoveries such as environmental factors that influence gender determination or pairing in the universe that can be inspired from the Glorious Qur'an. These investigations would encourage seeking the science and knowledge of creation, a religious obligation for the believer:

فَلَنْ سِيرُوا فِي الْأَرْضِ فَانظُرُوا كَيْفَ بَدَأَ الْخَلْقَ

Say: Travel in the earth and see how He started the creation.⁴⁴

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