

Jewish Genes: References to Genetics in the Torah

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The Bible and Talmud are honored and studied as sources of Jewish law (halacha) and tradition. However, they also contain knowledge about and insight into many other areas of study. This article discusses references to genetics in both of these sources.

The Talmud seems to be familiar with various genetic concepts. In Chulin 69a, the Gemara states that a ben pekuah, a fully developed fetus found inside the womb of a slaughtered animal, is permitted for consumption. However, if the ben pekuah protrudes its limb before its mother is killed, then that limb is prohibited, while the rest of the animal may be eaten. The Gemara considers the situation in which the ben pekuah that protruded its limb lives and has an offspring and discusses whether the entire offspring or the simply the limb corresponding to its parent's forbidden limb is prohibited. The Gemara explains that if the position is taken that "a limb gives birth to a limb," then the corresponding limb alone is prohibited. However, if the position that "[the father's] seed is commingled" is followed, meaning that all of the father's parts combine together to produce the offspring, then the entire offspring is prohibited.

The Gemara then rejects the first possibility, that each of the parent's limbs produces each of the offspring's limbs, stating that if this were true, then a blind or lame father would produce blind or lame offspring, respectively [1]. The Gemara's conclusion that "[the father's] seed is commingled" shows insight into the way that genetic material passes from parents to offspring. Genetic information that determines all of the parents' physical characteristics, or phenotypes, is passed to their offspring and determines their phenotypes.

A famous debate regarding whether a person's characteristics are determined by nature or nurture is hinted to in Yuma 47a. The Gemara states that Rabbi Shmuel ben Kimchi could scoop up four kabin (a certain unit of measurement) in his hands. Explaining the reason for his large hands, he says "All women received zarid, but my mother's zarid rose up to the roof." Although Rashi comments that the phrase "rose up to

the roof" means that his mother's zarid was the strongest, there is a disagreement as to what is the meaning of the word zarid. One explanation is that it refers to a cereal product of wheat, which Rashi explains pregnant women ate for nourishment. Accordingly, R. Shmuel ben Kimchi declares that his large hands are a result of nurture. A second opinion explains that zarid means semen, meaning that his mother's egg was fertilized by his father's "best" sperm. In this light, his large hands were a result of nature, the genetic material contributed by his parents.

In addition to insight into these debated genetic concepts, the Gemara ostensibly has knowledge of another genetic principle. When many science textbooks describe the history of genetics, mention is made that the first recorded knowledge of sex-linked genetic traits is found in the Talmud in reference to hemophilia. Hemophilia is a sex-linked recessive trait manifested by insufficient blood clotting. Hemophilia A, or classical hemophilia, and hemophilia B are caused by defects in the genes that code for the clotting protein factors VII and IX, respectively. Lacking proteins necessary for clotting, the blood of affected individuals does not clot properly and this can lead to excessive internal or external bleeding upon minor scrapes and cuts.

Healthy individuals have at least one normal gene, termed XH, while those with only the allele Xh have the disease. Since this gene is located on the X-chromosome, hemophilia is more common among males, who have a Y-chromosome and only one X-chromosome, which they receive from their mothers. Heterozygote females, having the genotype XHXh, are healthy, although they are carriers of the trait. This disease's mode of inheritance was determined in 1820, while it was given the term hemophilia in 1839. However, centuries earlier, the Talmud apparently understood the genetics behind this blood clotting disease. The Gemara in Yevamot 64b states that if a woman's sons die from their circumcision (brit milah), her subsequent children are exempt from this mitzvah. Rabbi Yehuda Hanasi says that the death of two sons

from circumcision is sufficient to set a precedence, while Rabban Shimon ben Gamliel requires the death of three. Both agree, however, that the phenomenon of insufficient blood clotting is an inherited trait.

Post-Talmudic rabbis show a further perception of the inheritance pattern of hemophilia. The Rambam rules in accordance with the opinion that the mother's third son should not be given a brit milah and adds that this is true even if the sons are from different fathers [2]. The Kesef Mishna notes the basis of this extension, pointing out that the Gemara says "if [she] circumcises her first son," using the feminine term "mala," instead of the masculine term "mal" [3]. This halacha is in line with the inheritance pattern of hemophilia. Women carriers married to healthy men have a 50 percent chance of passing this disease to their sons. Additionally, if a mother is a carrier, there is a chance that her siblings have the gene, as well. Her brothers, who contribute the Y-chromosome only, cannot pass this gene to their sons, but her sisters can pass the trait to their sons. The Gemara continues with a story which confirms this understanding, relating an incident of three sisters whose sons died during circumcision. Upon the birth of a son, the fourth sister approached Rabban Shimon ben Gamliel, who instructed her not to give her son a brit milah. From this Gemara, it is clear that although the term hemophilia is not used in the Talmud, the rabbis had a concept of how this sex-linked disease is transmitted and used this knowledge to exempt potential hemophiliacs from the mitzvah of brit milah [4].

Knowledge of genetics can be traced to an even earlier source than the Talmud—to the Bible itself. Parshat Vayetzei of the book of Bereishit relates a strange incident of how Yaakov seems to use magical means to establish his own flock from that of Lavan. Yehuda Felix, professor emeritus of both Botany and Talmud at Bar Ilan University, explains how Yaakov used genetic concepts, not magic, to build his flock [5].

In his financial negotiations with Lavan, Yaakov requests that rather than pay him wages, Lavan should remove "the spotted and speckled sheep and brown sheep and spotted and speckled goats, and of such shall be my hire" (30:32). Felix explains that the color of sheep and goats is determined by autosomal genes. The dominant color for sheep is white and for goats is black, while the recessive for both is what the Torah terms "spotted and speckled." In this article, S will denote the dominant allele and s the recessive allele of this trait. In this deal, Yaakov gave Lavan all of the

speckled (ss) animals currently in the flock and tended to the remaining flock, which was all dominantly colored, but contained animals of the genotypes SS and Ss. Lavan agreed to give Yaakov all of the spotted animals born from the white sheep and black goats, as Lavan assumed that their number would be few. Ordinarily, Lavan's assumption would be correct; however, Yaakov was able to increase the number of speckled animals born using his knowledge of genetics.

If the SS animals mated with either those of genotype SS or Ss, their offspring would be dominantly colored and would belong to Lavan. To establish his own flock, Yaakov needed to mate the Ss animals with other Ss animals, or perform the monohybrid cross, of which 25% of the offspring are ss. In order to accomplish this, Yaakov needed to distinguish between the SS and Ss animals, although both were solidly colored. The Torah states that "Yaakov took rods...and peeled white streaks in them" and placed them in front of the flocks at the watering troughs, "that they should conceive when they came to drink" (30: 37-38). Yaakov relates that an angel appeared to him in a dream and told him that "the rams that leaped upon the flock were streaked, speckled, and grizzled" (31: 12). In genetic terms, the angel was telling Yaakov that those animals that were first to mate also carried the recessive trait for spottedness. This is in accordance with the genetic concept of hybrid vigor, in which heterozygotes (Ss) have some advantages over the homozygous extremes (SS or ss). Here, the benefit of the genotype Ss is manifested in an earlier readiness to mate. Through this distinction, Yaakov mated the heterozygotes to each other. He separated the homozygote dominant (SS) animals from the flock and gave them to Lavan. The Torah states, "So the feebler were Lavan's and the stronger Yaakov's" (30: 42). Through using the angel's insight into genetics, Yaakov was able to build a substantial flock for himself. Professor William Etkin points out that even though Yaakov could have accomplished this task without the rods, he used them so that Lavan would interpret the extraordinary events in terms of superstitions. Etkin further notes that Yaakov does not mention the rods in his recounting of the dream, indicating that he understood that they were not significant [6].

These pieces of the Talmud and Bible show that knowledge of genetic principles are found within ancient Jewish sources. Perhaps when scientists named Gregor Mendel as the father of genetics, they were a few years too late.

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References:

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