

Jacob's Epigenetics: Spare the Rod or Spoil the Flock

By Rachel Siegel

One of the most famous debates that exists in genetics is the question of nature versus nurture. Are individual differences a result of a person's innate makeup, or are differences due to one's personal experiences? Nevertheless, genetics is a lot more complicated than a simple separation between nature and nurture. To start, nature and nurture are so intertwined that there is often no clear line between the two. Additionally, Bob Weinhold, who has written about environmental health issues since 1996 as a member of the Society of Environmental Journalists, writes in the journal *Epigenetics: The Science of Change from the Environmental Health Perspectives* that a science referred to as epigenetics has recently been gaining notice and credibility. He continues that it has been linked to many phenomena, including, but not limited to, cancers, cognitive dysfunction, as well as respiratory, cardiovascular, reproductive, and autoimmune diseases [1]. Epigenetics involves changes in gene activity that get passed down to the next generation of offspring without the altering of genetic code. Such modifications are controlled by epigenetic tags located just outside the genome that turn on and off the expression of particular genes. These tags can be passed on to the next generation. Not only has the fresh focus on epigenetics transformed the conventional discourse regarding nature and nurture, but the recent revival of epigenetic research legitimizes the thought seen throughout ancient Biblical text; external stimuli can determine physical characteristics of subsequent generations.

In ancient secular and Jewish societies, it was believed that characteristics obtained during one's lifetime were passed on to his or her offspring. This is contrary to the common notion in modern science, which states that heredity is not affected by characteristics obtained from the environment itself [2]. In fact, there are quite a few cases throughout the Talmud that suggest that "what you see is what you beget" [3]. In Brachot (20a), the story is told that Rabbi Yochanan would sit outside bathing houses, women would gaze at his beauty after immersing, and as a result they would have beautiful children. The Talmud continues discussing this idea and states that after immersing in the bath house, a woman should be careful about what she looks at on her way home, so as not to affect her offspring when she conceives [2]. Similarly, in Avodah Zara (24b), the Talmud explains that in order to produce a red heifer, an Israelite placed a red cup in front of two cows as they mated, causing the heifer to be born red. Furthermore, in a story found in Bereshit Rabbah (73:10), a black man and a black woman gave birth to a white child. The black man went to Rabbi Yehuda HaNassi to question whether or not the

child was his own. Rabbi Yehuda HaNassi asked the man if he had any white mirrors in his household, to which the man answered in the affirmative. Rabbi Yehuda HaNassi consequently attributed the pale color of the child's skin to the white mirrors in the couple's home. Likewise, Gittin (58a) describes Roman behavior during intercourse before and after the destruction of the Temple. Before the destruction of the Temple, the Roman noblemen wore rings with beautiful human figures during intercourse, and after the destruction of the Temple they forced attractive Jewish slaves to stand in the room while the Roman noblemen had intercourse.

Perhaps most prominent of the "what you see is what you beget" stories in ancient literature is the narrative of how Jacob received his wealth from his father-in-law, Laban. After Jacob married Leah and Rachel, he worked for Laban so that he could leave his father-in-law's house with a livelihood. During this time, Jacob made a deal with Laban which stated that Jacob would be able to keep all the spotted sheep that were born to the flock of sheep that he was herding. To spoil this deal, Laban gave Jacob a herd of only white sheep to watch over. However, Jacob figured out a way to ensure the success of his deal. Jacob took rods from trees and peeled back their bark, revealing a streaked pattern, and placed them in the water-troughs of the sheep. As a result, "the flocks conceived at the sight of the rods, and the flocks brought forth streaked, speckled, and spotted [sheep]" (Genesis 30:39).

This partiality in texts towards the idea that heredity can be affected by a parent's experiences was validated by Lamarckian inheritance, a theory published by Jean-Baptiste Lamarck, a plant biologist, in 1809 his book, *Philosophie Zoologique*. Lamarckism is described as an organism's ability to pass characteristics that were acquired during its lifetime to its offspring, through a change in physiology due to experiences or behavior. For example, according to Lamarck, when a giraffe stretches its neck to reach leaves high up in a tree, its neck muscles are strengthened and its neck becomes slightly longer. Therefore, the offspring of this giraffe will have somewhat longer necks. However, according to the Darwinian theory of evolution, which combined with Mendelian genetics has become the accepted view of modern genetics today, a genetic mutation would engender a giraffe to have a slightly longer neck than the giraffe's contemporaries. Because the giraffe with the longer neck has the ability to reach higher leaves on trees, an advantage for obtaining food, this trait would ensure the survival of the giraffe with the mutation, and thereby, the mutated gene will be passed

on to the next generation [4]. The widespread acceptance of modern genetics casts doubt on Lamarckism, therefore Lamarckian inheritance was never seriously considered to be legitimate.

Even if the aforementioned Talmudic stories seem farfetched, the Biblical story of Jacob's inheriting an abundance of wealth from Laban can be explained through Mendelian genetics. When Jacob suggested to Laban that he would keep the spotted sheep that would come from a flock of only white sheep, Jacob must have known something significant about genetics to have the confidence to devise a plan where seemingly, he could potentially work for many years without any payment. White is a dominant trait among sheep, and although Laban only gave Jacob the white sheep, two-thirds of these sheep would be heterozygotes for speckles. This means that two-thirds of these sheep's genotypes included genetic material for white wool as well as speckled wool, but because white is the dominant color over speckled, only the white genes were expressed. If the heterozygotes mated, there would be a twenty five percent chance of the parent sheep bearing spotted sheep in the first generation. Yet, if any homozygotes mated with the heterozygotes, all of the offspring would appear white. When Jacob recounts what happened to his wives, he says that an angel came to him and said, "Lift up now thine eyes, and see, all the he-goats which leap upon the flock are streaked, speckled, and grizzled" (Genesis 30:12). In a dream, the angel reveals to Jacob how to distinguish between the heterozygous and the homozygous sheep. The heterozygotes showed "hybrid vigor," meaning they had an increased rate of conception compared to the homozygotes. In Genesis (30:41-42), it states that "the stronger of the flock did conceive, that Jacob laid the rods before the eyes of the flock in the gutters, that they might conceive among the rods; but when the flock were feeble, he put them not in; so the feeble were Laban's, and the stronger Jacob's." The hybrids are referred to as Mekusharot, which means stronger, and the pure breeds are referred to as Atufim, or feebler. Jacob gave Laban all the homozygotes, the feebler sheep, while he kept all the heterozygotes, the stronger sheep. The speckled rods that Jacob put in the water-troughs was simply a method used by shepherds when mating their sheep. According to Dr. Yehuda Feliks, a former professor emeritus of Talmud and Botany at Bar-Ilan University, this practice had nothing to do with the birth of spotted sheep from white sheep [2]. In fact, when the angel appeared to Jacob, the angel made no mention of the need to place the spotted rods in front of the water troughs [5]. In the book, *Genesis and the Big Bang*, the renowned physicist Dr. Gerald Schroeder maintains that the sticks were strictly placed in front of the sheep to startle them backwards, increasing the rate of sexual intercourse between the sheep. He too asserts that the speckles on the rod did not contribute to the birth of speckled sheep [4]. In addition, when Jacob recounts what

happened between him and Laban, he makes no mention of the speckled rod to his wives. This implies that Jacob believed there was a genetic mechanism involved in the transfer of speckles, rather than the rods influencing the offspring [5].

On the other hand, there is one major logistical hole when reconciling Mendelian genetics and the story of Jacob and Laban. Rashi on Genesis 30:38 states that when "[t]he female animal saw the rods, it was startled at the sight of them and recoiled; its mate then pairing with it, it afterwards gave birth to young in the likeness of the rods to which they were exposed." Dr. Schroeder leaves out the part of Rashi that exclaims "in the likeness of the rods to which they were exposed" when proposing his theory. The Eitz Yosef, a commentator on the midrash that this Rashi is based off of, expounds on this idea. He emphasizes that, "[b]ecause of the recoil which came as a result of the appearance of the rods, the image of the rods remained in their imagination at the time of mating..." which "has an effect at the moment of conception." Additionally, the midrash relates the story of the black parents having a white child, immediately after its comment about "the likeness of the rods," intimating a similar phenomenon between the two stories regarding the influence of imagery during relations. Rabbi Shmuel Eidels (1555-1631), also known as the Maharsha, speculates that the story about the beautiful Rabbi Yochanan sitting outside the bathing house and the story of Jacob's sheep stem from the same principle that the image in a woman's mind during intercourse can influence her offspring. In his commentary on the red heifer, Rav Yaakov Emden relates the strange phenomenon of passing a red object in front of the cow during mating to what Jacob did with the rods [4]. Therefore, it seems that according to Rashi, the startling of the sheep during intercourse created "a hereditary imprint." This is similar to the concept of memories being encoded genetically in our DNA using electric shock, and is supported by the hypothesis that women discern colors more sharply during ovulation [3]. Altogether, the majority opinion among scholars seems to relate the incident of Jacob's sheep to Lamarckism.

The resurgence of epigenetics in the recent decade can not only help to scientifically explain the story of Jacob and Laban, but can also cast some validity on the other stories in ancient texts that relate to Lamarckism. Ernst Mayr, a major evolutionary biologist of the 1900's, explains the story of Jacob's sheep through the lens of Lamarckism. However, Dr. Schroeder vehemently disagrees with Mayr's explanation. Dr. Schroeder believes that Mayr's opinion is influenced by preconceived notions from the time when Lamarckism was believed to be true. However, now Lamarckism's viability has resurfaced [4]. As a matter of fact, Professor William Etkin, author of *Jacob's Cattle and Modern Genetics. A Scientific Midrash*, points out that all "Jewish authorities seem to accept the validity of the

obvious inference that the visual experience of the parents may determine the pigmentation pattern of the young,” and this renewed interest in epigenetics restores the logical validity of the Jewish authorities as well [5]. An article in *Newsweek* (published on January 26, 2009) gives several examples of Lamarckism shown in research. One example is that of fleas with helmets. When a female flea is attacked, as a defense she develops a helmet for further protection, but if a female flea is not attacked in her lifetime, she will not generate this helmet. Female fleas that produce a helmet during their lifetime give life to offspring with helmets, even though their actual DNA sequence doesn't change. Furthermore, *Time Magazine* published an article in 2010 that showed the effects of one generation's eating habits on its offspring. In a 2011 issue of the journal, *Cell*, research portrayed that stress can affect offspring without any changes to DNA sequences [4].

Particularly relevant to epigenetics and the story of Jacob and the sheep is the fair amount of research relating to “the role of prenatal nutrition on epigenetic events” [6]. There are four dietary sources of methyl groups; choline, methionine, vitamin B-12, and folic acid. An abnormal amount of any of these four sources can lead to abnormal methylation of DNA, which regulates gene expression by turning on and off the expression of specific genes [7]. The color of the viable yellow agouti mouse (*Avy*) ranges from yellow to mottled to pseudo-agouti, or brown. The more methylation on the *Avy* gene, the more agouti colored mottling appears on the mouse. Feeding pregnant mice diets rich in methylated substances has shown to change the phenotype of offspring to be more mottled than the mother [8]. The passage in Genesis (30:37) specifies that Jacob peeled the bark off of poplar, almond, and plane trees. Dr. Josh Klein, a plant pathologist at the Volcani Research Institute of the Israeli Ministry of Agriculture, posits that fungi containing methionine and choline can be found underneath the bark of these trees, and can be extricated through water [6]. These substances could have been responsible for the mottling of the offspring of the copulating sheep via methylation. Additionally, the pseudo-

agouti mice also showed to live healthier, prolonged lives than the yellow mice, which is referenced in Genesis 30:41-42, where it is explained that “when the flock were feeble, [Jacob] put them not in; so the feeble were Laban's, and the stronger Jacob's” [8].

The ideas of Lamarckism do invite skepticism. After all, there are many experiences that parents have which are not passed down to their offspring, such as their moral compasses. Moreover, sheep that graze in green grass don't have green offspring. However, epigenetics is a resurrection of Lamarckism in the sense that environmental factors do affect the phenotypes of offspring. Lamarck's theory doesn't specify a mechanism through which this could be explained, but epigenetics provides a very rational system through which the effect of environmental factors on the next generation can be attained. Curiously, most articles that argue the knowledge of Mendelian genetics in the story of Jacob are written before 2000. Many of the articles written later on view the story through the lens of epigenetics. Both views are clearly influenced by the science of their times in an attempt to reconcile Torah with science. It is possible that Jacob, and the scholars who commented on this story, had very little understanding of genetics, but it is very clear that there is a scientific way to explain what occurred. The more we discover in science, the more the brilliance of G-d and His genetics is palpable during this episode between Jacob and Laban. As a result, this consciousness regarding the brilliance of G-d increases one's sense of awe towards the hidden miracles at work.

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