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A GENETIC ANALYSIS OF THE EVENTS LEADING TO THE BIRTH OF DINAH

An individual's understanding of any subject matter is influenced by life experiences and prior knowledge. People with divergent secular backgrounds will interpret specific aspects of the Torah from their own distinctive viewpoints. For example, Rabbi Aryeh Kaplan had a strong scientific background and his understanding of the resurrection of the dead focused on molecular genetics. [1] Apparently, he assumed that the miracles surrounding resurrection would occur according to established biological principles (or, simply, the laws of nature). In a similar approach, this presentation is a biologist's view of a specific miraculous birth described in the Torah and expounded upon by the commentaries; the event will be explained as being guided by *HaShem* to occur through existing biological principles.

Verse 21 in chapter 30 (*Parshat Vayaitsay*) of *Beraisheit* states, "And afterwards she bore a daughter and called her name, Dinah." This refers to the birth of Dinah to Leah. On the surface, this seems a typical birth of a girl; however, as will be noted, this pregnancy was far from typical. Rashi and the *Gemara Berachot* (page 60a) comment on the word "afterwards" and on the choice of the name, "Dinah."

"Afterwards" implies that initially the fetus was male and only afterwards was the fetus female. Leah already had six sons and the maid-servants, Bilha and Zilpa, each had two sons. Thus, the forerunners of ten of the twelve tribes were already born. Leah reasoned that if this seventh pregnancy produced another son, subsequently, Rachel would be destined to have only one son. If so, then Rachel would not even contribute to the people of Israel as many tribes as did the maid-servants. Therefore, Leah prayed that this fetus be changed from a male to a female. This judgment that Leah passed on herself was evident in the name, Dinah, which stems from the word for judgment ("*din*").

Another explanation for the name, Dinah, is found in *Beraisheit Rabbah* (72, 6), which states that the origin of the name is from the word, "*dayainu*" (or, "we have enough"). In this scenario, Leah, Bilha, and Zilpa all prayed "*dayainu*." Based on either explanation, the prayers focused on Leah's seventh pregnancy producing a female, rather than a male, child. *HaShem's* response was that Leah's fetus was changed *in utero* from a male to a female.

The Maharsha commenting on *Gemara Berachot* (60a) quotes the *Midrash Tanchuma*, which noted that the phrase "And afterwards..." ("*achar*") is in the masculine, rather than in the feminine, form. The use of the masculine form was an indication that initially the fetus was a male, but after the prayers, the developmental biology of the fetus was altered to yield a female.

The *Gemara Berachot* (60a) also notes that these prayers were offered during the first forty days of Leah's pregnancy. A *baraita* is then cited that until the fortieth day a husband is permitted to pray that his wife's pregnancy will result in a son; thereafter, it is prohibited. As will be noted, this specific time limit is in accord with present day concepts of human fetal development. However, the *in utero* change of the gender of a human fetus is not a normal occurrence. The *Gemara* refers to this specific gender alteration as a miracle. It states that *halacha* cannot be learned from Leah's pregnancy, because *halacha* may not be derived from a miraculous event. We suggest that this miracle was directed by *HaShem* to occur according to existing principles of molecular genetics.

The explanation, however, necessitates a brief background in basic genetics. Each human has 46 chromosomes, or more precisely, 23 pairs of chromosomes, in each nucleus of each body (somatic) cell. One chromosome from each pair is derived from that person's mother (contributed in the egg and termed the maternal chromosomes) and the other chromosome from each pair is derived from that person's father (contributed in the sperm and termed the paternal chromosomes). Chromosomes of a pair are morphologically alike. There is one exception, chromosome set number 23, which is referred to as the sex chromosomes. In a human male the chromosomes of this pair are dissimilar and consist of one large X chromosome with many genes and a much smaller Y chromosome with few genes. In a human female, however, this set consists of two large X chromosomes. Human females produce eggs, each with one X chromosome while males produce two types of sperm, an X chromosome-containing sperm and a Y chromosome-containing sperm. If an X chromosome-containing sperm fertilizes a human egg with its one X chromosome, the resulting individual will develop into a female (XX). If a Y chromosome-containing sperm fertilizes a human egg with its one X chromosome, the resulting individual will develop into a male (XY).[2,3]

Initially, a human fetus is potentially hermaphroditic, in that it has two types of embryonic tubes, the Wolffian and Mullerian tubes, and a bipotential gonad, that is, tissue that has the potential to develop into either the ovary or the testes. The Wolffian tubes are forerunners of the male reproductive tract and the Mullerian tubes are forerunners of the female reproductive tract. If the fetus is female(XX),the Wolffian tubes degenerate and the Mullerian tubes develop into the oviduct and uterus and the bipotential gonad into the ovary. This process can be viewed as passive, in that, the fetus will develop into a female unless something actively hinders this process. [2,3]

If the fetus is male (XY), a gene on the Y chromosome becomes activated at about the fortieth day and produces a regulatory protein that induces the bipotential gonad to differentiate into the testes. This gene, initially termed the testis-determining factor (TDF)-gene and now termed the sex-reversal on Y (SRY)-gene, is located on the terminal portion of the small arm of the Y chromosome and is believed to play a major role in directing a series of events that culminate in the development of a male. In this sequence, the bipotential gonad develops into the testes and produces testosterone, which stimulates the Wolffian tubes to develop into the male reproductive system; Mullerian inhibiting substance is also produced by the testes and the Mullerian tubes never develop and eventually degenerate. [2,3]

It should now be evident why the *Gemara* stresses day forty. It states that prayers regarding the gender of the fetus are fruitless after this time; after the fortieth day the fetus is already programmed to follow a specific developmental pathway regarding its gender. It is also

interesting to note that embryological development follows the scheme established by *HaShem* in creating the first Adam. Rashi (*Beraisheit* 1:27) notes that the first Adam was an hermaphrodite. Similarly, every fetus initially has both the Mullerian and Wolffian tubes and a bipotential gonad. Later in development, the gender is determined by the absence or presence of the Y chromosome. [2,3]

Chromosomes, at times, break and the wrong ends may recombine. Suppose a mistake occurs and the terminal portion of the Y chromosome breaks and reattaches to an X chromosome; this type of chromosomal aberration is termed a nonreciprocal translocation. Further suppose that this occurs in the testes, specifically in a cell destined to become a sperm. This sperm then carries one full X chromosome that has attached to it the small portion of a Y chromosome with the TDF gene. If this sperm fertilizes a normal egg, the resulting fertilized cell, or zygote, will eventually develop into a sterile male. In human populations, about 1 in 20,000 males is XX with the TDF gene on a small portion of the Y chromosome that has attached to the paternal X chromosome. This male is sterile because the gene for male fertility is on the long arm of the Y chromosome. [2,3]

To further explain the nature of the miracle, the concept of dosage compensation needs to be understood. Under normal circumstances, all cells of a human male contain 46 chromosomes, which include an X and a Y chromosome; all human females have cells with 46 chromosomes, that include two X chromosomes. However, at about day 16 of embryonic development, one X chromosome inactivates in each cell of the female fetus. This inactivated chromosome is evident as the so-called Barr body noted in epithelial cells only from females. Which X chromosome inactivates, the one contributed by the person's father or the X chromosome contributed by the person's mother? Research has shown that the pattern is random and in some cells the paternal X chromosome inactivates and in other cells it is the maternal X chromosome that inactivates. Inactivation of the X chromosome does not occur in the male. Thus, both human males and females have only one active X chromosome (i.e., they have the same dosage of active X-linked genes).[2,3]

With this brief background, we can now begin to understand, perhaps, the dynamics of the gender change with regard to Leah's seventh pregnancy. Genetically, this fetus was derived from the fusion of a normal egg with a sperm that contained a chromosomal translocation, specifically, an X chromosome with the small portion of the Y chromosome with the TDF gene. Thus, this fetus would be destined to develop into a male, albeit, a sterile male. In cases of structural abnormalities in an X chromosome, dosage compensation may not be entirely random, as the abnormal X chromosome is preferentially inactivated. The prayers offered by Leah and apparently accepted by *HaShem* may have lead to the inactivation of only the paternal X chromosome with the TDF gene in each embryonic cell of the fetus. The result of such a nonrandom dosage compensation would lead to the inactivation of the TDF gene and, thus, subsequently to the development of a female fetus, or Dinah.

This explanation also appreciates the merit received by Leah for her unselfish prayers regarding Rachel's welfare. Without Leah's prayers the fetus would have developed into a male, who as a result of sterility could not have been a founder of one of the 12 tribes. Thus, Leah was rewarded with a healthy female child.

The miracle was extended to Dinah. Dosage compensation, most probably does not occur in the ovarian cells destined to become eggs. Thus, some of Dinah's eggs would contain a

normal X chromosome and others would contain the X chromosome bearing the translocated small portion of the Y chromosome. What about Dinah's probability of having normal children? For Dinah to have normal children, whether sons or daughters, requires that only those eggs with the normal X chromosome are fertilized. Each conception had a one in two chance of resulting in a healthy child. As no "unusual" offspring are noted in the Torah, it can be assumed that the miracle may have extended to the offspring of Dinah, in that, these children were normal.

The above presented hypothesis is most probably oversimplified. It is not intended to suggest that the birth of Dinah occurred naturally, without the intervention of *HaShem's* will. The *in utero* sex change was a miracle! However, it is suggested that this miracle may have followed a prescribed pattern of molecular genetics. The probability of a father producing a sperm with a translocated piece of the Y chromosome on an X chromosome, coupled with the probability of this specific sperm out competing the other millions of sperm that are produced and race to fertilize the egg, and further coupled with the probability of a nonrandomized dosage compensation occurring in <u>each</u> cell of the fetus, resulting in inactivation only of the translocated paternally-derived X chromosome, is highly improbable and unlikely. The probability of such independent events occurring is expressed by the "product law," which states that the probability of two or more outcomes occurring simultaneously is equal to the product of their individual probabilities. For example, the probability of the paternally-derived X chromosome inactivating in a single fetal cell is ½; the probability of this occurring in two fetal cells is ½ x ½; the probability for inactivation of the paternally-derived X chromosome in <u>each</u> fetal cell is $(½)^n$, where n is the total number of fetal cells at the time of dosage compensation. The resulting probability value would then be multiplied by the probability (1:20,000)of the birth of a viable fetus with two X chromosomes, with the paternally-derived X chromosome bearing the terminal portion of the Y chromosome with the gene for maleness. That the above-noted sequence of improbable events <u>may</u> have occurred according to biological principles, albeit under the direction of a Divine plan, is precisely why it is a miracle.

NOTES

1. Aryeh Kaplan, Encounters (Brooklyn: Moznaim Publishing Corporation, 1990), pp. 125-128.
2. N. V. Rothwell, Understanding Genetics. A Molecular Approach (New York: Wiley-Liss, Inc., 1993), pp. 91-126.
3. P.J. Russell, Genetics (New York: Harper Collins College Publishers, 1996), pp. 47-96.

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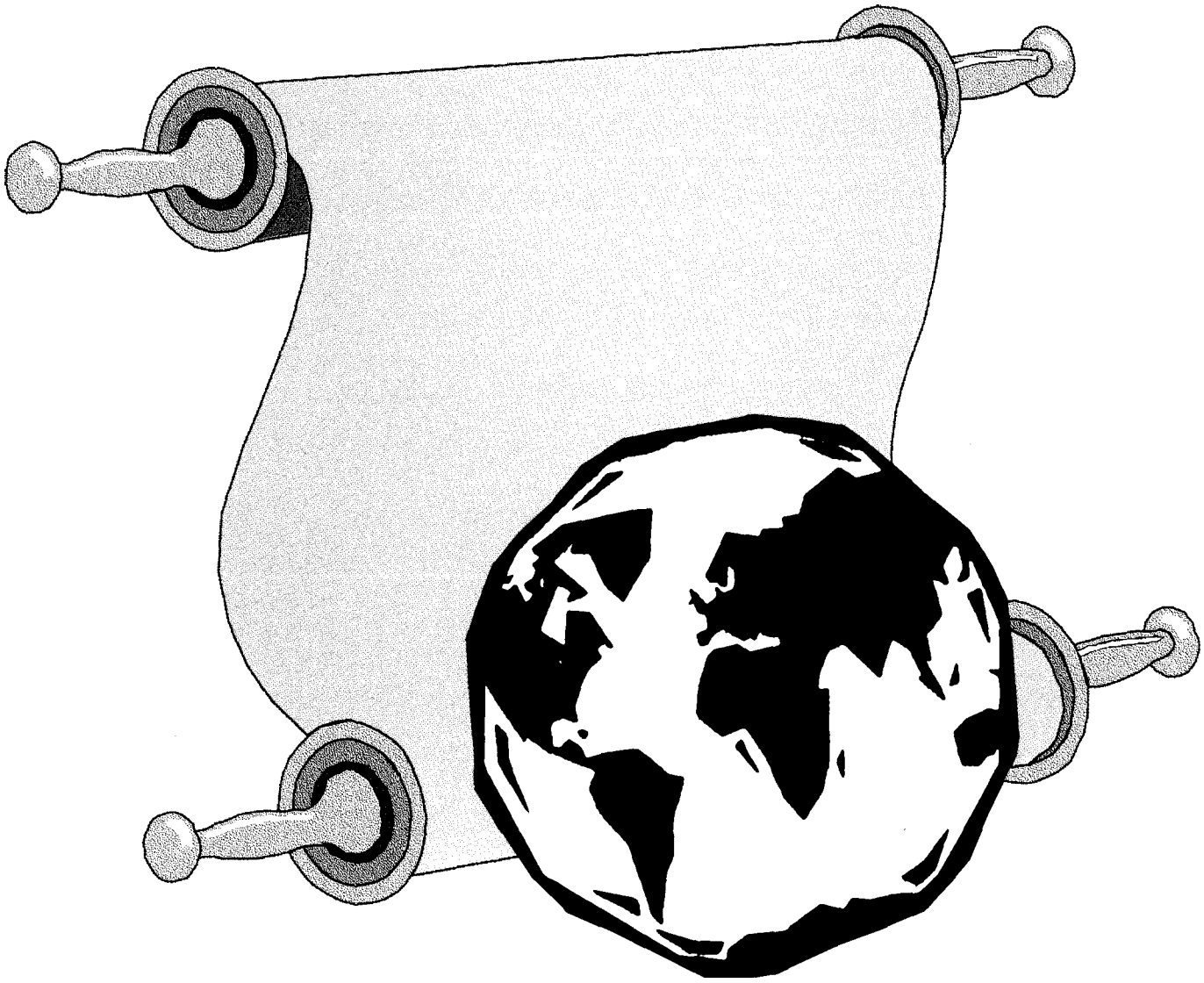

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