

TEKHELET - A CHEMICAL CONUNDRUM

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“...And they shall place upon the *tzitzit* of the corners [of the garment] a thread of *tekhelet*” (*Bamidbar* 15:38).

“You shall make the *mishkan* of ten curtains twisted linen and *tekhelet* and *argaman* and *tola’at shani*...” (*Shemot* 26:1).

“You shall make the robe of the *ephod* entirely of *tekhelet*” (*Shemot* 28:31).

These verses represent a mere sample of the myriad references made to the pigment of *tekhelet* in the Torah. Conventionally translated as the color turquoise, *tekhelet* has become nothing short of a mystery to its seekers. The *chilazon* is the source of *tekhelet* (*Shabbat* 26a), yet the identity of its species is fraught with uncertainty. As such, the Midrash states that the *tekhelet* has been concealed and today we possess only white *tzitzit* (*Bamidbar Rabba* 17:5) [1]. Because of this anonymity, the majority of observant Jews continue the tradition of not using *tekhelet*. In relatively recent times, however, there has been a concerted effort to re-determine the nature of *tekhelet* and the process of its production.

The color of *tekhelet* has long been associated with royalty and nobility, as can be seen from the verse, “clothed in *tekhelet*, governors and rulers...” (*Yechezkel* 23:6). The vestments of the *Kohein Gadol* were sewn of *tekhelet*-dyed wool and the palace of King *Achashverosh* was adorned with the piercing blue, as well (*Esther* 1:6). The *Gemara*, in *Menachot* 44a specifies that “the *chilazon* emerges from the water once every seventy years and with its blood *tekhelet* is dyed; therefore, *tekhelet* is expensive.” *Rashi* comments that the rarity with which the *chilazon* appears on land is the reason for its astronomic cost. This could provide an understanding as to why the color was found mainly in the company of the wealthy. In fact, it was precisely the harvesting of the *chilazon* that gave the tribe of *Zevulun* its great wealth. When Moshe blessed *Bnei Yisrael* before his death, he declared to *Zevulun*, “...for by the riches of the sea they will be nourished and by the treasures concealed in the sand” (*Devarim* 33:19). The Talmud, in *Megilla* 6a,

discloses that the “treasures” refer to “white glass” and the blood of the *chilazon*.

Recent chemical evidence has led scientists to believe that the *chilazon* is, indeed, the *Murex trunculus* snail, which was used by the Phoenicians to dye their garments.

In various and disparate locations, the *Gemara* gives several criteria by which the *chilazon* is identified. Why, then, is this creature unbeknownst to us today? The answer lies in the fact that our tradition gives specific criteria for the *chilazon*, but several species would have to be combined to meet those criteria. Some of the physical characteristics include:

- Its appearance on land once every 70 years (*Menachot* 44a).
- Its anatomy is like that of a fish (*Menachot* 44a).
- It is captured with nets that are lowered into the water (*Shabbat* 74b).
- Its capture on *Shabbat* is prohibited by *tzad* (*Shabbat* 75a).
- The method of dye extraction from the *chilazon* is described as “*potzea*”, the cracking of a hard surface (and not *korea*, which would imply the ripping of flesh) (*Shabbat* 75a).

Descriptions of the *tekhelet* itself are given, as well:

- Its blood is collected in a separate sack, and does not diminish the life of the *chilazon* upon extraction (*Tosfot, Ketuvot* 5b).

- The dye is of better quality when extracted from a live *chilazon* (*Shabbat* 75a).
- The color of *tekhelet* from the *chilazon* is identical to that of *kala ilan* (indigo) (*Bava Metziah* 61b).
- *Tekhelet* is permanent and does not fade with time nor wash out of the dyed wool (*Menachot* 43b).

Even though so many details are known about the *chilazon* and the *tekhelet*, the question still remains as to why the manufacture and wearing of *tekhelet* ever fell out of practice? There has been much speculation about the disappearance of *tekhelet*. No doubt ever existed in our tradition as to the identity of the *chilazon* or the process of *tekhelet* production. The falling from practice of dying with *tekhelet* was not a result of suddenly forgetting how to accomplish the task. It was due, rather, to the political decrees of Rome, as well as the enormity of its cost. During the supremacy of the Roman Empire, emperors, among them Valentinian, Theodosius, and Arcadius, proclaimed an official prohibition against the public production of *tekhelet*. They restricted the wearing of this royal color only to certain nobility, threatening capital punishment to those who disobeyed. Thus, the great danger associated with the use of *tekhelet* caused it to become lost as the generations passed. Additionally, the production of *tekhelet* was very expensive, even for the nobility who were permitted to use it. To appreciate the expense that *tekhelet* represented, in 301 BCE, one pound of *tekhelet*-dyed wool cost 50,000 *dinarii*, a salary of almost three years for a baker [2].

Throughout the ages, several proposals have been made as to the *chilazon's* identity. Although modern day evidence is not supportive, *Rambam*, *Rashi*, and *Tosfot* agree that the *chilazon* is a fish. This creature satisfies the first three criteria, but how, then, can its dye be removed by *potzea*, which would imply that the *chilazon* has a hard shell to be cracked or smashed? *Rashi* resolves the issue and proposes that in this context, *potzea* means “squeezing out” the blood, or dye, from the *chilazon*. Some maintain that because *tekhelet* is used in the construction of the *mishkan*, it must be derived from a kosher source. Others disagree and counter that the dye is used to color materials which necessarily adhere to *kashrut* laws; the dye, in and of itself, is not considered to be substantive and may, therefore, come from non-kosher animals [3].

A resurrection of the search for *tekhelet* came with the advent of a renewed Messianic enthusiasm of the nineteenth century. Religious leaders wrote and preached about the imminent redemption to the eager masses. Amid the excitement, were discussions regarding the rebuilding

of the Temple and the recreation of the priestly garb. A standstill was then reached; how could the holy vestments be made without *tekhelet*? Rabbi Gershon Henoch Leiner, the Radziner Rebbe, assumed the responsibility of finding the lost ingredient and the animal from which it comes. He traveled to an aquarium in Naples to investigate a suggestion that the *chilazon* was the squid, *Sepia officinalis*, or as more commonly known, the cuttlefish. He consulted with the chemists of his town and found that its black ink secretions could be turned to blue. The Talmudic descriptions of the anatomy of the *chilazon* and its blue dye now paralleled his discovery. In three treatises, *Sefunei Temunai Chol*, *Petil Tekhelet*, and *Ein HaTekhelet*, R' Leiner identified the *chilazon* as the cuttlefish.

In 1913, as part of his doctoral dissertation on *tekhelet*, Rabbi Isaac Herzog, Chief Rabbi of Dublin and subsequently Chief Rabbi of Israel, contacted eminent chemists and dye experts in Germany for an analysis of the *tekhelet* of the Radziner Rebbe. The shocking results showed that the deep blue was, in fact, an inorganic dye known as ferric ferrocyanide, $Fe_7(CN)_{18}$, or Prussian blue. Upon request for the methods of *tekhelet* production used by the Radziner Chasidim, Rabbi Herzog noted that the ink was heated to very high temperatures and iron filings were then added to the hot liquid. Through this procedure, organic molecules in the ink decomposed. The carbon and nitrogen atoms recombined with the iron, producing the deep blue pigment. Thus, the Radziner's *tekhelet* was not from the squid, but from an inorganic substance that could be produced from a generic chemical reaction. It represented the recombination of the atomic components of any number of molecules. Rabbi Herzog decided that the Radziner Rebbe's formula could not be true *tekhelet*, as the Talmud goes to great lengths to specify the requirement of a specific biological species. He proffered, instead, that the *chilazon* could be the *Janthina* snail [4].

In the mid-1800's, archaeologists unearthed several “factories” where dye was produced. Near these structures were large piles of snail shells, among them, the *Murex trunculus* [2]. Recent chemical evidence has led scientists to believe that the *chilazon* is, indeed, the *Murex trunculus* snail, which was used by the Phoenicians to dye their garments. The dye of the *Murex trunculus* undergoes a series of transformations, from colorless to yellow to green to blue, and finally, to purple [5]. Because *tekhelet* should be purely indigo, the presence of purple is very enigmatic. In the 1980's, Otto Elsner of the Shenkar College of Fibers investigated the ancient technique of exposing the dye to the sun. He and Ehud Spanier of Haifa University

researched this method even further and found that when the *M. trunculus* dye is in a chemically reduced state and subsequently exposed to any form of ultraviolet light, the purple hue completely disappears. Thus, the dye naturally reduces upon exposure to sunlight, which would explain the method of old [4].

The biochemistry of the *in vivo* dye production was later explained. The precursors of the dye are in the snail's hypobranchial gland as a clear, colorless liquid. Upon the liquid's exposure to air and sunlight, an enzyme known as purpurase converts it into the dye. The reaction produces a mixture of the blue indigo and the purple dibromoindigo. The sunlight causes the carbon-bromine bonds to break and the molecule is transformed into indigo, or *tekhelet*. Because of the rapid denaturation of purpurase, the gland must be squeezed immediately from the living mollusk, which is a criterion consistent with the *Gemara's* description that the

animal remain viable after the extraction of the dye [4]. Rabbi Dr. Moshe D. Tendler, *Shlita*, writes that though no single individual can testify that he has received a tradition as to the identity of the *chilazon* and *tekhelet*, the knowledge that has surfaced from research and investigation is almost incontrovertible. Thus, "...the matter is equivalent to the testimony of two witnesses, whose word is sufficient to establish a matter" [2].

The complexity of the modern reestablishment of *tekhelet* is truly fascinating. It reflects the beautifully unwavering devotion of the Jew to *HaShem* and His commandments. The tireless efforts of those determined to find the *chilazon* and study the manufacture of its dye have hopefully contributed to the nearing of our final redemption. May we merit once again to see the *tekhelet*-colored constituents of the third and final Temple speedily in our days.

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