One of the enduring mysteries of Jewish life following the exile of the Jews from the Land of Israel was the disappearance of the observance of including a string of techeiles in the tzitzis garment that Jews wore. Techeiles was known to be of a royal blue color while the other strings of the tzitzis were white in color. Not only did Jews stop wearing techeiles – they apparently even forgot how it was once manufactured. The Talmud identified techeiles as being produced from the “blood” of a sea creature called chilazon. And though the Talmud did specify certain traits and identifying characteristics belonging to the chilazon, that description was never specific enough for later generations of Jews to unequivocally determine which sea creature was in fact the chilazon. It was known that the chilazon was harvested in abundance along the northern coast of the Land of Israel from south of present-day Haifa to just north of present-day Tyre in Lebanon (Shabbos 26a). Though the techeiles itself disappeared from Jewish life as part of the damage of exile, the subject of techeiles was discussed in the great halachic works of the ages. Just as the Jews did not forget Zion and Jerusalem, their subconscious memory of past glory and spiritual greatness kept techeiles alive in their memory if not in actual practice.

There are a number of basic questions that require study in order for any determination of the possibility of actually observing techeiles in our time to occur. The three main questions are: 1) When and why did techeiles disappear from the Jewish world? 2) Which sea creature is actually the chilazon and how can blue dye be manufactured from it?; and 3) Even if the chilazon can be positively identified and techeiles processed from it, is it within our halachic power to revive a “lost” commandment, the tradition (mesorah) of which has also been lost? These questions, which have always existed and been discussed in halachic and rabbinic literature, began to move from the realm of purely intellectual and speculative to the arena of actual Jewish practice about one hundred twenty five years ago. Since then, the search for the chilazon and the debate about renewing the observance of techeiles has been intensified until it now has achieved the status of discussion regarding practical behavior and observance.

There have been various dates and reasons attributed to the demise of techeiles in the Jewish world. In the ancient world (and later in the world of Rome), the colors of purple and blue were reserved for royalty and the upper classes. The Romans were especially jealous of their governmental monopoly on producing dyes for the royal purple and blue. The Talmud records the arrest of two rabbis from Israel who were smuggling techeiles into the Jewish community of Babylonia (Sanhedrin 12a). The Talmud also records that techeiles was brought to Babylonia in the time of Rav Achai c500 CE (Menachos 43a). There is no specific reference in the Talmud that Jews were not able to obtain and wear techeiles. Since the final redaction of the Babylonian Talmud occurred c570 CE, Rabbi Isaac Halevi Herzog, the late Chief Rabbi of Israel, in his seminal work on techeiles assumes that the techeiles manufacturing factories in the Land of Israel were destroyed during the time of the Moslem conquest of the country in c638. In any event, the range of dates advanced for the disappearance of techeiles in the Jewish world extends from the late fifth century (Rabbi Yehoshua Kutner in Yeshuat Malko, Orach Chaim, 2:1-3) to the fifteenth century with the fall of Constantinople to the Moslems in 1453 (mentioned by Rav Herzog as a possibility, though he personally rejects it.) Mar Shalom Gaon (died 859), Rav Nachshon Gaon (died in 889) Rav Shmuel ben Chafiai Gaon (died 1034), Rav Yitzchak Alfasi (died 1103), Rambam (died 1204), and many other great Geonim of Babylonia and Rishonim of Spain and France bemoan the disappearance of techeiles from the Jewish scene. From all of this it seems clear that techeiles was no longer available by the time of the zenith of the Moslem conquests in the Mediterranean basin and the Balkans in the seventh century. Rabbi David ben Zimra (Radvaz) of Cairo stated at the end of the fifteenth century that chilazon may certainly yet exist in the waters of the Mediterranean but that “we are unable to harvest it.” This situation remained in effect until the end of the nineteenth century.

As for the remaining two questions regarding techeiles – the identity of the sea creature called chilazon and whether a “lost” commandment and tradition can be revived after centuries of absence – there entered on the scene in 1889 Rabbi Gershon Henoch Leiner, theRadzyner Rebbe. Rabbi Leiner claimed that the chilazon was a squid and he actually produced thousands of sets of tzitzis that included a blue string made from a dye.
obtained from that squid, which he believed was techeiles. He defended his contentions in a massive three-volume work of Torah scholarship entitled Sfei Tmunei Chol, Psil Techeiles, and Ein Hatecheiles. However, Rabbi Herzog in his 1913 dissertation already proved that Rabbi Leiner’s squid was not the chilazon. Rather, he advanced the theory that the chilazon was a snail, Murex trunculus, that had been discovered in Mediterranean waters by a French zoologist, Henri Lacaze Duthiers, in 1857. However, Rabbi Herzog was disappointed by the fact that the dye obtained from this snail was purple in color and not the blue indigo necessary for techeiles. The problem that Rabbi Herzog raised was solved by a chance discovery of Otto Elsner of the Shenker Institute in Tel Aviv in the early 1980’s. He discovered that the liquid obtained from the gland of the snail, when exposed to the Aviv in the early 1980’s. He discovered that the liquid extracted from the gland of the snail, when exposed to the air turns purple in color. However, during the dyeing process, when it is exposed to direct sunlight it turns into a brilliant indigo blue. The many thousands of Jews who wear techeiles today in their tzitzis obtain their techeiles strings from the dye of this Murex trunculus snail (except of course for the Radzyner Chasidim who follow their Rebbe’s opinion that a squid was the chilazon.) There seems to be little doubt today that the snail, Murex trunculus, is indeed the long-lost elusive chilazon.

The question of reviving techeiles use has been hotly debated in rabbinic circles for over a century. Rabbi Yosef Dov Soloveitchik, the rabbi in Slutzk and Brisk in the middle and late 1800’s, discussed Rabbi Leiner’s techeiles and rejected it. Unfortunately, the Beit Halevi’s actual responsa was lost and two versions of his reckoning have come down to us. The Radzyner Rebbe, quoting the Brisker Rav in order to answer his objection, presents Rav Soloveitchik’s contention that since this squid was well known to the rabbis of all the ages, yet they did not regard it as being the chilazon, this in effect constitutes a negative tradition regarding equating the squid with the chilazon. However, if the chilazon was instead found to be a newly discovered sea creature that was unknown to the rabbis throughout the centuries, the lack of rabbinic tradition would not necessarily disqualify the techeiles produced from this recently discovered sea creature; assuming, of course, that the prospective chilazon and techeiles met the criteria set forth in the Talmud. Within the Brisk family, though, a different line of reasoning is attributed to the Beit Halevi. They claim that the Brisker Rav required a positive tradition regarding the identification of the chilazon, and once that line of mesorah was broken, the halachic determination of the chilazon and wearing techeiles derived from it would have to wait for Messianic times (see Rav Yosef Dov Soloveitchik, the Beit Halevi’s great grandson, in Shiurim L’zechor Abba Mari Z’l vol. 1, p. 228). Clearly, this discrepancy regarding the Beit Halevi’s position has ramifications regarding techeiles obtained from the Murex trunculus since the recent discovery of the existence of this snail and the even more recent discovery of how to obtain blue indigo dye from its gland, would be sufficient in terms of the first position attributed to the Brisker Rav, and on that basis some feel that it is obligatory to wear techeiles in our very time.

There is a statement in the Midrash (Midrash Tanhuma (Shelach 28); Bamidbar Rabba (17:5)) that techeiles was “nignaz” – “put-away/hidden.” There are those that maintain that this statement also precludes the use of techeiles in our time. But it seems clear that this was not the intention of Midrash, especially since techeiles was still in use after the time of the writing of this Midrash. Rabbonin such as Rabbi Yecheil Michal Tikutchinsky have interpreted the Midrash as meaning that techeiles became less and less common but not that it disappeared completely, nor was this Midrashic statement intended to prevent the use of techeiles amongst Jews of later generations. There is no unanimity in current rabbinic opinion regarding this question of the reintroduction of techeiles into Jewish life and practice, though as an empiric observation the use of techeiles continues to spread widely throughout the Jewish people. One thing is certain, techeiles has become a living issue and has left the exclusivity of the study hall and entered into the everyday life of tens of thousands of Jews the world over.

Principles Regarding Tying
Tzitzis with Techeiles
Collected Sources

Although the method for tying white tzitzis is fairly standardized, the situation regarding tzitzis with techeiles is the subject of widespread machlokes. There are many aspects dealt with by the gemara and Rishonim:

Number of strings on each corner

The Rabbis taught, How many strings does one place [on each corner]? Beis Shamai say four and Beis Hillel say three...

Menachos 41b

Ratio of white to techeiles strings

How many strings must one place? Not less than three - this is the opinion of Beis Hillel. Beis Shamai say: Three [strings] of [white] wool and a fourth of techeiles. And the halacha is according to Beis Shammai.

Sifre Shelach (115)
Sifre Ki Tetzei (234)

*Note: The Vilna Gaon claims that the correct version of this Sifre is "כ"כ בתו הינו של בן רבי ויצ.activity, "With three strings of white and a fourth of techeiles." This change would harmonize the two quotes from the Sifre.

There are three different opinions of the Rishonim regarding the ratio of white to blue strings:

- **Rambam** (תלמוד בבלי א�:ו) - Half of one string (when folded becomes one of the eight strings) is techeiles. The Rambam understands the posuk in Bemidbar in the following manner: put upon the fringe of each corner (= white one thread of blue). Only the windings (פתיל) around the white core (כנגד שבעה רקיעי) must be techeiles.

- **Raavad** (uação ולב אב א"א) - Based on the Sifre in Shelach hold that one full string (when folded it becomes two of the eight) must be techeiles.

- **Rashi** (סנהדרין סא כ) and Tosfos (נסנהדרין סא ט) - Two full strings (four of the eight) are techeiles.

**Issues regarding the windings (krichos)**

We learned in the Mishna, When one begins, he begins with white - “[the fringe of each] corner,” the same kind as the corner [i.e. The same color as the garment]; And when one concludes, he concludes with white - one always increases holiness and never decreases.

Menachos 39a

There is an argument as to the explanation of this passage:

- **Rav Amram Gaon** (רמבן מעייני ב') holds that the first chulya is white, the next is techeiles, and so on alternating white and techeiles for seven or thirteen chulyos. These chulyos of alternating colors are termed I'sayruyn.

- **The Raavad** (ורובא אב א"א) holds that the first twist of the first chulya and the last twist of the last chulya are white, and all the other twists are techeiles.

- The **Kesher Elyon** (קשר עליון) explains that each chulya is white, the next is techeiles, and so on for seven or thirteen.

There is an argument as to the nature of the knots of the tzitzis. The Geonom (טרנסקית: על ממיתים) hold that a knot can be one string tucked under itself. Rabbenu Tam (מחות/machot) compares the knots of tzitzis to knots in other laws like Shabbos and therefore requires a double knot. According to Rabbenu Chananel, the knot is made by looping one string around the rest, whereas the Mordechai concludes, he concludes with white - all the strings are used (by looping four around the other four). Menachos 39a

**The Knots**

- **Kesher Elyon** (קשר עליון): The uppermost knot is required from the Torah.

**Double or single knots**

There is an argument as to what the numbers seven and thirteen refer. Most Rishonim explain that these numbers refer to the amount of chulyos (each of which is made up of three twists as Rebbe states). Some Rishonim explain that each chulya can have between seven and thirteen twists, and they explain Rebbe’s three twists as referring either to the number of techeiles twists in each chulya (and the number seven includes both the white and the techeiles), or that Rebbe is talking about the absolute minimum required to fulfill the mitzva (bedieved deoraysa), but the best method (techatchila derabanan) should have between seven and thirteen twists.

**Color of twists**

- תנחל מڅ 돌아ח מڅ (aretz mefits, חמיים בלב), " Encore, "מי נסן: כסאות.
- מפים, מפרשים בלט - מחלקה בטקע עם מורים.
- מנהל טל.

Rabba says, this implies that the upper most knot is required from the Torah. Menachos 39a

Rashi says, this implies that one must tie a knot after each and every chulya. Menachos 38b

**Five Knots**

- קירץ, ששת, ששת, שמונת, חמשה, חמשה, חמשה, חמשה, חמשה, חמשה וෆוחת.
- חמשה, חמשה, חמשה, חמשה, חמשה, חמשה, חמשה, חמשה, חמשה, חמשה חמשה.
- [The word] tzitzis is numerically equivalent to 600, 8 strings and 5 knots adds up to 613.

Tanchuma, Korach 12

**The length of the windings and the strings**

We learned in the Mishna, When one begins, he begins with white - “[the fringe of each] corner,” the same kind as the corner [i.e. The same color as the garment]; And when one concludes, he concludes with white - one always increases holiness and never decreases.
Rav Huna said in the name of Rav Sheses in the name of Rav Yirmiyah bar Abba in the name of Rav: The most ornate techeiles ought be a third windings, and two thirds hanging threads. Menachos 39a

Various opinions regarding the krichos for tzitzis with techeiles

Disclaimer! Very few Poskim define their shittah in complete detail. Often they discuss one issue (for example, alternating the colors of the chulyos), but leave another (e.g. the type of knot) unexplained. In the following list of shittos, some details are the result of speculation in order to determine a complete practical method of tying.

The principles discussed above are applied differently by the Poskim. The numbers correspond to the accompanying picture. The following is an (incomplete) list:

1. Rav Amram Gaon - seven or thirteen chulyos alternating white then techeiles. A knot at the beginning and at the end (according to the Baal Haitur, a knot after each chulya). (These knots are not double, but rather the winding string tucked under itself. According to the Shaalos U’tshuvos Binyamin Zeev, the knots are double knots.)

2. The Raavad according to Rav Natronai Gaon - five knots. Between each knot, seven to thirteen twists, with the twists alternating white then techeiles. Between the second and third knot, the amount of twists is not definite, but most probably still alternate between techeiles and white.

3. Tosfos - first a double knot, then one chulya of white and one of techeiles, then a second double knot, again white then techeiles and a knot, then again white and techeiles then a knot, and finishing with one white chulya and a double knot. This has seven chulyos and five knots.

4. The Chinuch - thirteen chulyos, alternating white and techeiles distributed between five double knots. Between the first and second knot - three chulyos (white, techeiles, white). After the second knot another three chulyos (techeiles, white, techeiles). After the third another three (white, techeiles, white), and after the fourth - four chulyos (techeiles, white, techeiles, white).

5. The Vilna Gaon - thirteen chulyos, alternating white and techeiles distributed between five double knots. Between the first and second knot - four chulyos (white, techeiles, white, techeiles) and the same between the second-third, and third-fourth knots. Between the fourth and last knot - one chulya of white.

6. The Rambam - all twists are techeiles except the first and last. Seven or thirteen chulyos are tied with a knot between each that keeps them together and separate from each other. The Yemenites have a tradition (even with white tzitzis) of tying each chulya into a special knot.

7. The Rambam with double knots after each chulyah – In the example shown here, the knots are double knots. Note also that the strings here are according to the opinion of Tosafos.

8. The Rambam according to the Radzyner - has all the twists techeiles except the first and last. There are five knots: between the first and the second knot there are seven twists, between the second and third - eight twists, between the third and fourth - eleven twists and between the fourth and last - thirteen twists (similar to the way we tie tzitzis without techeiles). Each group of three is separated by winding the techeiles around and inside them to hold them together.

9. Another understanding of the Rambam – The thirteen chulyos are tied with the Yemenite knot, and are distributed between five double knots. Four chulyos between each of the first four knots and one chulya between the fourth and last double knot.
Kala Ilan
Rabbi Dr. Ari Zivotofsky

The Gemara in Menachos (41b) states:

“תכלת וקלא אילן - כל מיני-טלית שכולה תכלת. ר”ת

The Rabbis taught in a Baraisa: With respect to a garment that is made entirely of techeiles, threads of all colors satisfy the tzitzis obligation in it, with the exception of kala ilan.

Rashi explains the reason why the kala ilan dye is unacceptable:

ודמי תכלת ויוו תכלת לפי הלשון רביעיICONICSLRIYKN

Since it is similar to techeiles and it may happen that the tallis is passed to another person who assumes all the strings are made of techeiles. And when he needs them for another tallis, he will take two strings from this tallis and put them on the other one… and he will have kala ilan with white on the tzitzis thus making kelaim without any mitzvah.

Kala ilan is a fraudulent dye which is visually indistinguishable from the more expensive techeiles. It is therefore imperative to ensure that one not substitute kala ilan for techeiles either maliciously or by accident. As the Gemara explains previously (Menachos 40a), the mitzvah of placing techeiles on one’s tallis overrides the issur of shaatnez, and as such, one is obligated to put techeiles (which by definition is of wool, c.f. Yevamos 4b) on a tallis made of linen. This, of course, is true only when using authentic techeiles, but if the wool strings are dyed with the counterfeit kala ilan, the prohibition of shaatnez would remain intact, hence the gezeirah against any use of kala ilan was instituted in order to avoid any possible confusion. (c.f. הלקות קטות לאור (מאתרות) הלכות ציצית).

Although the white (i.e. non-techeiles) strings of the tzitzis can theoretically be made of any color, the gezeira against using kala ilan (instead of white) is so severe that Rav Moshe Feinstein felt that even if one had true techeiles strings that were afterwards dipped in kala ilan (to increase their luster), they would still be prohibited. (Iggros Moshe, Yoreh Deah, vol. 2; 133)

Since kala ilan was identical to the much more expensive techeiles, unscrupulous people might attempt to pawn off strings dyed with it in place of genuine techeiles. The Sifri (Bamidbar, 115) warns against this:

“אני אל хочם שישו מהז家长们 אוסבס מקור מדרים. כי

The idea is brought down in a number of additional places including Bava Metziah (61b), Rashbi on the posuk in Shema (Bamidbar 15;41), and Sheilotos Dr’Achay Gaon Vaera 43. These sources show that the similarity between kala ilan and techeiles is absolute, in that only Hashem can distinguish between them. Nevertheless, this assertion is challenged by the Gemara in Menachos (42b):

The Rabbis taught in a Baraisa: Techeiles has no means of examination, and therefore, it may be bought only from an expert… Does techeiles actually have no means of examination? But Rav Yitzchak the son of Rav Yehudah would test [techeiles] for authenticity. (BeGeSHem is a mnemonic for the items that he used in his test.) He would bring alum, sap of fenugreek, and urine that is forty days old, and he would soak [the techeiles] in them from evening until morning. If its color faded, [the thread] was deemed unfit, for fading indicates that it is kala ilan, and if its color did not fade, it was deemed fit, for this indicates that it is genuine.

The Rambam (Hilchos Tzitzis, 2;5) agrees that although the two are visually identical, chemical tests can distinguish between kala ilan and techeiles. It is generally agreed that the tests recounted here are difficult to understand and are therefore inconclusive.

Kala Ilan and Isatis

The Aruch defines kala ilan as indigo (מיסוף) and the Mosif adds “Binyamin said: That is its Greek name, it is a type of dye that is similar to techeiles.” The Nemukay Yosef also identifies kala ilan with indigo and the color blue. The Teshuvos Hageonim (333) notes that in Arabic it is called nil (which is indigo).
Another dye mentioned by Chazal as similar to techeiles, and identified with the Arabic nil is isatis (アジア), (Kafir Vafarach, ch. 48, Radvaț in Teshuvat 685, Rav Bartenua on the Mishnah in Kelaim 2; 5, Pachad Yitzchak, vol. 4, p. 78 – see Rav Shlomo Teitelbaum in Lulaot Hatecheiles, pp. 235-240).

Although both isatis and kala ilan both denote indigo and are both similar to techeiles, the terms are not used interchangeably. (The Rambam (Hilchos Tzitzis, 2; 1) does seem to use isatis in place of kala ilan. Most probably the two were associated with different plants which both produced the same dye (indigo). Isatis referred to the woody plant, (Isatis tinctoria) which is indigenous to the temperate regions of northern Europe, while kala ilan corresponded to Indigofera tinctoria which was cultivated in warmer climates (specifically China and India) and yields much higher concentrations of indigo.

Kala Ilan and archaeology

In 1961, Yigal Yadin excavated a cave near Ein Gedi which served as Bar Kochba’s command center. Yadin found an archive of letters, documents and other artifacts that shed light on the life of the leaders and participants of the Great Rebellion against Rome. One of the finds was “a bundle of wool… wrapped in a piece of wooden mantle with colored bands and a linen cloth.” The chemical analysis of the wool showed it to be dyed with a mixture of indigo and kermes (which is the Biblical tolaat shani). Yadin came to the conclusion that “this wool was intended for the petit techeiles of the ritual tassels (tzitzis).” Since the wool was dyed with plant indigo and not that derived from a chilazon, Yadin came to the conclusion that this was in fact kala ilan, and not real techeiles.

Subsequent investigation and deliberation regarding Yadin’s find have raised serious doubts as to whether the bundle of wool was intended for use as tzitzis. Professor Feliks also wonders why the fraudulent dye ostensibly used in place of the more expensive genuine color would incorporate tolaat shani, which was at least as costly as techeiles! Yadin also “proves” that the wool was used for tzitzis from the fact that it was tied with a linen cord, and that this was done deliberately since tzitzis must be shaatnez. This, of course, does not correspond to the Halachah as we know it. Taking all this into consideration, the question of Yadin’s find and its link to kala ilan and techeiles is still quite tenuous. (See Rav Menachem Borshiten’s discussion of this in Hatecheiles, Sifraiti, 1988, pp. 73-74 and the picture of the actual wool found in the Cave of Letters on page 48 no. 8)

The indecisive nature of this find notwithstanding, people continue to refer to Yadin’s find as categorical evidence of the discovery of ancient tzitzis with techeiles.

Significantly, archaeological excavations have uncovered tzitzis belonging to bar Kochba’s soldiers. Only one of the eight strands was dyed techelet.

(Moznaim edition English translation of the Rambam, Hilchos Tzitzis, page 199 footnote) This goes so far as to claim that Yadin found techeiles strings according to the shitta of the Rambam! Needless to say, this assertion is unsubstantiated.

Kala Ilan as a basis for identifying true techeiles

Kala ilan and techeiles are impossible to tell apart (at least with the naked eye), and so one should be able to make use of this property when attempting to identify true techeiles. If one finds a candidate for the techeiles producing chilazon, the most important test would be to see if the color of the dye is the same as that of indigo. In fact, the argument can be taken one step further, namely, that if one finds any marine organism that yields a dye which is fast and the color of indigo, then that dye must be kosher for techeiles. This is the opinion of both of the greatest authorities on techeiles – Rav Gershon Henoch Leiner of Radzyn and Rav Yitzchok Eizik Halevi Herzog. The Radzyner writes:

The Chinese character for indigo (lan) is made up of three elements – an eye, a person, and a vessel with water. Taken together, this represents a reflection in the water (perhaps of the sky).

Rav Herzog (Biblical Blue, page 94) suggested a number of possibilities explaining the origins of the term kala ilan. Kala in Sanskrit means black or deep blue and nilam is indigo (similar to the Arabic nil). Kala ilan may mean the kala derived from trees (ilan in Hebrew) or perhaps it is a corruption of kala-nil(aman). Rav Herzog also posits that the Chinese lan (= indigo) might be involved. This may be leaned additional support by the fact that in ancient Chinese, the term for indigo was actually k’lan which is very similar to kala ilan (Indigo Textiles, Gösta Sandberg, Black, 1989).

Origin of the term kala ilan

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Radzyn and Rav Yitzchok Eizik Halevi Herzog. The Radzyner writes:
If, after searching we would be able to find the blood of any kind of *Chilazon* that would enable us to properly dye the color of *techeiles* which would retain its original beauty and would not fade, then certainly we would be able to fulfill the *mitzvah* of *techeiles* without any doubt.

(Sefunei Temunei Chol, page 14, 1999 edition)

Both Rav Herzog (The Royal Purple and Biblical Blue, Keter, 1987, page 73) and the Radzyner offer the same line of proof for this assertion. If there is another *chilazon* whose dye satisfies these criteria, but is not kosher for *techeiles*, then why would Chazal not warn us regarding its use? The only caution recorded in the *Gemara* is with regards to *kala ilan* – indigo derived from a plant source – but there is no admonition against using another sea animal that is not the *chilazon shel techeiles*. Therefore, either that species’ dye is also kosher for *techeiles*, or there is only one species in the world (or in the Mediterranean) that satisfies both those criteria. In either case, any sea creature which produces a fast dye the color of indigo must necessarily be kosher for use as *techeiles*.

**Dyeing Techeiles**

*Dr. Baruch Sterman*

The Gemara in Menachos (42b) relates:

"Abaye said to Rav Shmuel bar Rav Yehudah: This thread of *techeiles*, how do you dye it? [Rav Shmuel bar Rav Yehudah] replied: We bring the blood of the sea creature *chilazon* and certain herbs, and we put them in a pot and boil it up. Then, we take a little bit of the dye in an eggshell and test it with a wad of wool. Then we spill out the dye left in that eggshell and we burn the wad of wool that was dyed for the purpose of testing."

The dye process recounted here is similar to that brought down by the ancient Greek and Roman scholars. Aristotle and Pliny the Elder describe the procedure used in dyeing the *porphyra*. Pliny elaborates on the method:

The vein of [the snail] is removed and to this salt has to be added... and it should be heated in a leaden pot, and with 50 lbs of dye to every six gallons of water kept at a uniform and moderate temperature by a pipe brought from a furnace some way off. This will cause it gradually to deposit the portions of flesh which are bound to have adhered to the veins, and after about nine days the cauldron is strained and wool that has been washed clean is dipped for a trial. (Natural History, Book IX. LXII. 133)

This procedure has been reenacted recently by researchers in England who have been able to produce beautiful blue dyed wool. With the advances in our understanding of dye chemistry, however, much more efficient methods can be used which yield results in a consistent and reliable manner.

*Techeiles* belongs to a group of colorants known as vat dyes. These must undergo specific chemical processing before they can be bound to fabric. One of the main characteristics of *techeiles* is its fastness - it does not fade with time or wash out of the wool. The Gemara (Menachos 43a) explains that even after chemical testing לא איפרד חזותיה – its color does not fade, or as the Rambam puts it (*Hilchot Tzitzit* 2:1) א ולשעומדת ביפיה – it remains beautiful and does not change.

This trait of steadfast stability in a dye translates chemically into the fact that the dye pigment does not readily bind to water or soap or other substances that could serve to remove it from the fabric. However, if a dye is hard to get out of the wool, it is equally hard to get it into the wool, i.e. to dye the wool in the first place! Overcoming this obstacle is the major difficulty facing the vat dyes.
The posuk in kriat shema says that by looking at the tzitzis one will remember all of Hashem’s mitzvot. Rashi explains that the word tzitzis is numerically equal to 600. Add to that the 8 strings and 5 knots, and you have 613, the number of mitzvot in the Torah. The Ramban and others disagree with Rashi and claim that it is actually the string of techeiles that serves as the reminder. The sky-blue thread evokes contemplation of the heavens and of God’s throne and that leads one to remember the mitzvot.

Interestingly, recent work by Dutch scientists* regarding the properties of the techeiles dye molecule, revealed a striking coincidence. The color of a substance is determined by way it reflects and absorbs light. No two molecules have the same pattern (called a wavelength absorption spectrum) which is measured in units called nanometers. Techeiles obtained from the Murex Trunculus snail derives its color from a sharp peak in its spectrum at exactly 613 nm.

\[
\begin{align*}
\text{Wavelength (nm)} & \quad 400 \quad 600 \\
\Delta A & \quad 613
\end{align*}
\]

In order to dissolve the techeiles molecule in water and introduce it into the wool, it must undergo the chemical process known as reduction. In ancient times this was accomplished through fermentation, where the meat and dye-containing parts of the snail were heated on a low flame for a few days (as described by the Gemara and by the classical scholars). Bacteria that live on the snail meat ferment the dye and reduce it. In modern times, that same result can be accomplished much more quickly by adding a strong reducing agent (such as sodium dithionite). In this reduced state, two important things can happen. Firstly, the dye molecule dissolves in water, and thus wool will absorb the solution and take up the dye. Secondly, the chemical bonds are weakened so that exposure to sunlight removes the purple tint from the dye molecule (that it has when taken from the snail) and leaves it the beautiful sky-blue that is techeiles.

When the dye is in the vat (יוהי), in the reduced state, it does not have same color that it will ultimately have in the wool, but rather the solution has a yellow-green hue, as can be seen in the accompanying picture. This may help to understand the second part of Rav Shmuel bar Yehudah’s statement (echoed by Pliny) regarding the need to “test” the dye by pouring out some dye into an egg shell and dipping wool into it. Why not just look at the dye solution and see if it is the right color? Since the dye in its reduced state gives no indication of the color that the dyed wool will have, the only way to accurately determine that is to actually dye some wool and bring it out of reduction by exposing it to the oxygen in the air. In the picture one can see the lustrous blue techeiles of the wool in its final state, while the bottom is still the same yellow as the dye solution.

The chilazon stores the compounds which can turn into techeiles inside a gland. (These compounds are actually part of the snail’s digestion of its food.) In order to become the dye, two additional things are necessary; an enzyme called purpurase, which is also present in the snail, and air. The enzyme decomposes quickly if the snail dies, and so the dye must be extracted and exposed to air while the snail is alive or shortly after its death. This accords well with the sugya in Shabbos (75a) which discusses whether breaking open a chilazon and extracting its dye should make one liable for the transgression of taking a life on shabbos, since killing the snail is actually detrimental to the dyeing process.

The longer it stays alive the more he is pleased in that the dye will be clear.

Additional educational material regarding techeiles is available from

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- Display of different shititos for tying techeiles
- Kit for actual dyeing of techeiles
- CD with approximately 300 articles on techeiles related topics
- The Mystery of Techeiles (Video or CD) available in English or Hebrew
- Tying Techeiles (Video or CD) available only in English