

THE SEARCH FOR Biblical Blue

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Even as the first freezing drop of water trickled beneath our wetsuits, we knew that this dive would be historic. We checked our scuba equipment one last time, and then slowly descended into the deep blue waters off the ancient Mediterranean port of Akko, in northern Israel. Our goal: to find the small snail used in ancient times to produce *tekhelet*, the brilliant blue dye prized in the Bible—but lost to the modern world.

For the first few minutes, we saw nothing. Then my dive partner and old school buddy Baruch Serman, a physicist who lives in Israel, purposefully reached forward to grab what looked like a rock. He flipped the “rock” over—it was in fact an algae-covered shell that had blended imperceptibly into its background. Before the dive, Rabbi Elyahu Tevger, the leader of our expedition, had precisely described the mollusk we were searching for and had shown us photos. Thanks to his training, Serman and I immediately recognized the “rock” as having the classic profile of the snail species—called in Latin *Murex trunculus*—that gave the ancient world the color blue.

We gathered about 150 of the 2- to 4-inch-long snails before our oxygen ran out, and we took our hoard to the ancient fortress of Akko. A crowd of Arab children gathered round to see what this odd group of divers and ultra-Orthodox Jews was doing in their waters. As Rabbi Tevger broke open a snail to show us how the dye was once extracted, the children yelled exuberantly “*chilzun, chilzun,*” the Arabic word for “snail”—an echo of the term *chilazon* used in the Talmud to describe the source of the biblical blue.

PHOTO BY EUGENE WEISBERG, TEL AVIV



PREVIOUS PAGES: A piece of white wool changes almost magically to blue after being dunked in a yellow chemical solution. The same dye solution was used in biblical times to color the curtain of the Temple, the covering of the desert Tabernacle and the rich robes of kings and priests. In the Torah, God instructs his people to “make for themselves fringes on the corners of their garments [and] attach a cord of blue (*tekhelet*) to the fringe at each corner” (Numbers 15:37) as a reminder to keep his other commandments. Wearing these fringes, or *tzitzit*, is a *mitzvah* (commandment) that observant Jews, including author Ari Greenspan, have always striven to obey.

But the chemical makeup of the biblical blue dye was a mystery until just a few years ago. In the accompanying article, Greenspan recounts how the modern world recovered biblical blue. The source: the unassuming Murex snail shown to the right of the beaker in this photo.

In the ancient world, colors and dyes held great social and economic importance. Dyes like *tekhelet*, extracted from rare sources, were used only by the wealthiest and the most powerful. The earliest extant references to *tekhelet* are business records. A cuneiform tablet from Ugarit (present-day Syria), dated to about 1500 B.C.E. records the amount of *takiltu*, “blue wool,” owed to a merchant.¹ A recently rediscovered and deciphered seventh-century B.C.E. Babylonian tablet in the British Museum contains the earliest known instructions for dyeing wool with the colors *takiltu* and *argamantu*.²

In the Hebrew Bible, “blue (*tekhelet*), purple (*argaman*) and scarlet (*tolaat shani*)” yarns are listed along with gold, silver and copper as gifts suitable for God (Exodus 25:4). The desert Tabernacle was made of ten strips of “fine twisted linen, of blue, purple and scarlet yarns, with a design of cherubim worked into them” (Exodus 26:1). The curtain that partitions off the Holy of Holies, the embroidered screen at the Tabernacle’s entrance and the priestly robes were also made of the same colors. In the Book of Judges, the booty taken from the Midianites includes the purple robes of kings as well as 1,700 shekels worth of golden earrings (Judges 8:26). When in the Book of Chronicles, Solomon asks Hiram of Tyre to send him workers to build the Temple, he specifically requests “an artisan skilled to work in gold, silver, bronze, and iron, and in purple, crimson and blue fabrics” (2 Chronicles 2:7). At the end of the Book of Esther, Mordecai emerges from the king’s palace dressed in “royal robes of blue and white, with a great golden crown and a mantle of fine linen and purple” (Esther 8:15).

In Jewish tradition, the blue dye *tekhelet* has a special role. In the Torah, the Israelites are commanded to wear at all times a *tekhelet*-colored thread:

The Lord said to Moses as follows: Speak to the Israelite people and instruct them to make for themselves fringes (*tzitzit*) on the corners of their garments throughout the ages; let them attach a cord of blue (*tekhelet*) to the fringe at each corner. That shall be your fringe; look at it and recall all the commandments of the Lord and observe them, so that you do not follow your heart and eyes in your lustful urge.

(Numbers 15:37-39)

To this day, observant Jews have striven to follow this *mitzvah*, or commandment, but it hasn’t been easy. The source for the biblical dye is not mentioned in the Bible, and although it is discussed in the Talmud and other ancient sources, the process for producing the dye was lost to the Jews. By the turn of the first millennium C.E., *tekhelet* was no longer available.

We don’t know for sure why *tekhelet* disappeared: Perhaps it was because of its





PHOTOS COURTESY OF THE AUTHOR



“TEKHELET RESEMBLES THE SEA, and the sea resembles the sky, and the sky resembles God’s holy throne,” according to the Talmud (*Menachot 43b*). The Talmud and other ancient sources guided author Greenspan to search for the source of *tekhelet* in the waters off the Mediterranean port city of Akko, in northern Israel. Here Greenspan’s dive partner, physicist Baruch Sterman, at right, and an interested rabbi examine the fruits of their search: the *Murex trunculus* snail (see photo, far left).

With algae covering its shell, the Murex snail blends humbly into its natural sea-floor habitat (near left). It has long been known, from classical writers and the discoveries of archaeology, that a gland in the body of the snail was the source of the brilliant purple dye used to color royal and priestly garments in biblical, Roman and Byzantine times. The Talmud says that the blue dye prized by Jews was also obtained from a snail (*chilazon*), one found in these same waters—a strong hint that both the biblical blue and purple dyes came from the same source. But a failure to understand the chemistry involved led many investigators astray.

The serendipitous discovery in the 1970s by a Tel Aviv chemist named Otto Elsner revealed the answer: Just leave the purple dye solution from the Murex snail out in the sun! The purple chemical dibromoindigo reacts with sunlight to lose its bromine atoms: What is left is indigo—similar to the brilliant blue of the sea.

high cost or because Jews had lost access to materials needed for its production. Perhaps production decreased because the dye's use was banned or limited in some way: In the Talmud, a city called Luz is identified as a place "where *tekhelet* is dyed"³; elsewhere, the Talmud tells of two men who are captured by Roman soldiers because "they had in their hands items made in Luz."⁴ In the Roman period, Julius Caesar and Augustus Caesar had restricted the wearing of purple garments to the ruling classes; Emperor Nero went even further and decreed that only he could wear purple.

It is possible royal blue fell under the same ruling.

At some point, a cheaper alternative was made available although this, too, fell out of use along with *tekhelet*. A blue dye made from the *kala ilan* plant (popularly known as indigo or woad) came to be used by unscrupulous merchants of *tzitzit*, despite many rabbis' objections. The dye from *kala ilan* looked just like *tekhelet*;⁵ the Talmud says that only God could distinguish between the two. But because the Bible specifically states that *tzitzit* be dyed with *tekhelet*, the rabbis cautioned their students to "only buy *tekhelet* from an expert" as a way of ensuring authenticity.⁶

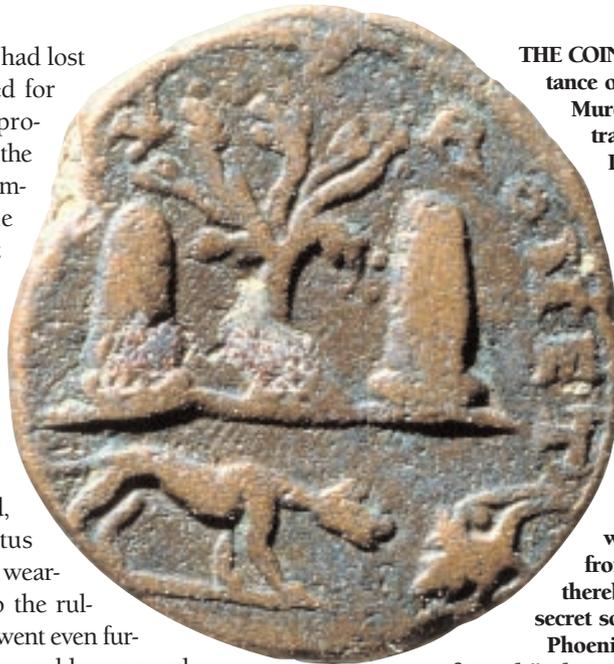
Despite the rabbis' efforts to maintain the use of *tekhelet*, by the end of the first millennium C.E. we find rabbis making statements like "we have no *tekhelet* in the present day"⁷ and "for many days we have not heard of anyone who has merited to wear *tekhelet* on his garment."⁸ The dye was lost. Only white *tzitzit* were worn.

For centuries after, people have tried to re-create the dying process. Their search for biblical blue reads like a detective story, with clues coming from the Bible, the Talmud, classical authors and medieval rabbis, archaeological remains and the serendipitous discoveries of modern scientists.

The Talmud, the authoritative compendium of Jewish law and lore,* is one of the most helpful sources for pinpointing the source of *tekhelet*. Yet, it has also provided some false leads.

The Talmud contains extensive discussions of *tzitzit* and of exactly how the commandment to wear them was to be followed. It does not specify how to make the dye, but it does give a generic term for the creature from which *tekhelet* was derived: *chilazon*, which

*The Talmud was written and collected between 200 B.C.E. and 500 C.E. It has come down to us in two versions, called the Palestinian Talmud and the Babylonian Talmud.



THE COINS OF TYRE reflect the importance of the dye industry—and of the Murex snails harvested for this trade—to this Phoenician city.

Located 25 miles north of Akko, on the Mediterranean coast of Lebanon, Tyre was the center of a lucrative dye industry in the ancient world. Many Tyrean coins such as this one depict not only the Murex snail (lower right on coin) but also the legendary discoverer of the mollusk's secret—Hercules's dog (lower left). One day, according to tradition, the pooch bounded out of the waves with lips stained purple from all the snails he had eaten, thereby revealing to mankind the secret source of the dye.

Phoenicia literally means the "Land of Purple"—deriving from the Greek word for purple, *phoinix*. But the Tyreans should now probably be credited with creating precious blue dyes as well.

is generally translated as "snail." Throughout history, however, some have argued that the term *chilazon* may refer to any mollusk—whether snail, squid, octopus, clam or other shellfish. This has caused great controversy over the true identity of the creature.

In the 15th century, Rabbi David ben Zamra, chief rabbi of Egypt, sounded a note of hope about the possibility of rediscovering the source of *tekhelet*. "It is possible that the species is still to be found, but it is not known how it can be fished."⁹ In the late 19th century, Rabbi Gershon Chanoch Henoah Leiner, the scion of the Hasidic Radziner dynasty, set off across Europe in an attempt to find the source of the lost *tekhelet*. His exhaustive research resulted in three volumes on the subject. In the end, he concluded that the Talmud's *chilazon* was the elusive mollusk *sepia officinalis*—a squid. (He'd seen one in an aquarium in Naples in 1888.) Rabbi Leiner succeeded in dying cloth blue with specially prepared squid's ink on the first day of Hanukkah in 1889, and then produced 10,000 sets of *tzitzit* for his followers. Most rabbinical authorities did not accept Rabbi Leiner's identification of the *chilazon*, however. The dye made from squid ink lacks the permanence ascribed to the ancient color, and it has no historic or archaeological record of use. A pamphlet condemning Leiner's *tekhelet* was published in 1891. It was called *Psil Tekhelet* (Invalid Tekhelet)—a play on the biblical phrase *P'til Tekhelet*, meaning "string of tekhelet."

In 1913, Rabbi Issac Halevi Herzog, who later became the first Chief Rabbi of the State of Israel, wrote his doctoral thesis at the University of London on *tekhelet*. Herzog was revered as a prodigy by all sectors of Judaism. What made him so spectacular was his immense secular knowledge: He was fluent in a dozen



ANCIENT DYE VATS (top) containing crushed Murex shells testify to the presence of the dye industry at the Phoenician site of Tel Dor. It is likely that snails were first cultivated in artificial pools (rather than being fished from the ocean); holding pools with channels leading to the sea to ensure fresh seawater have been found at several sites. The extreme permanence of the dye is shown on a sherd (left) from a limestone vessel that may have once contained dye solution, as well as in pieces of dyed wool (above) found in caves in the Judean desert where Jewish rebels hid out during the Second Revolt against Rome (132-135 C.E.).

languages, he wrote a 12-volume set contrasting Jewish, Roman and British law, and he had degrees in law as well as math. Herzog concluded that the *Janthina* mollusk was the best option to identify a true source of *tekhelet*.¹⁰ *Janthina* has only one thing going for it: The shell is a beautiful violet blue, “the color of the sea” as the Talmud states. But nobody has ever succeeded in making any color dye but brown from it.

Fish, squid, *Janthina* snail—none of these suggestions

works well with the evidence from ancient authors and modern science.

Geography is perhaps our best clue to identifying the *chilazon*—and thus, *tekhelet*. The Babylonian Talmud relates that when an old man near Achziv, on the



PHOTOS COURTESY OF THE AUTHOR

A HANDFUL OF WOOL, removed from the dye solution and oxidized through contact with air to become a deep, rich sea-blue (right) is the end product of the *tekhelet* dying process. The wool is then ready to be used to make the blue threads woven into the *tzitzit*, ritual fringes (above) that hang from the edge of a *tallit* or prayer shawl. Different traditions of how to wrap and tie the fringes are shown here.



was so important to the Phoenicians that they were named for it: *Phoinix*, in Greek, means purple.

Fortunately, the biblical purple, unlike biblical blue, has left a clear record of its manufacture and use in the ancient world. Following the purple trail will lead us to the source of *chilazon*. As we shall see, it's no coincidence that *argaman* and *tekhelet* are almost always mentioned together in the Bible.

northern Israeli coast, was asked, "What is your profession?" he answered: "I am a *tekhelet chilazon* fisherman."¹¹ Elsewhere the Talmud suggests that *chilazon* come from the portion of land allotted to the tribe of Zebulun—that is, the region in northern Israel between the Sea of Galilee and the Mediterranean.¹² The Talmud also tells us that the dye-producing *chilazons* are found between the cliffs of Haifa and Tyre.

The mention of Tyre, the leading trade center and port of the Phoenicians, is an important tip-off to the *chilazon's* identity. In antiquity, the Phoenicians were responsible for the production of the priceless purple dye called *argaman* in the Bible. Indeed, the industry

Classical sources make frequent reference to Tyrian purple, as does the Bible. Remember that King Solomon asked the Phoenician king Hiram of Tyre to send him artisans skilled in working "purple, blue and crimson" to decorate the Temple.

The first-century C.E. Roman historian Pliny, in his *Natural History* speaks of a "mad lust for purple" and reports that "the best Asiatic purple comes from Tyre. He even explains how the purple dye was produced, beginning with its extraction from the Murex snail: "The Murex ... has the famous flower of purple, sought after for dyeing robes, in the middle of its throat. Here there is a white vein of very scanty fluid from which that

precious dye suffused with a dark rose color, is drained.”¹³

In 1858, French zoologist Henri de Lacaze-Duthiers confirmed Pliny’s identification of the snail as *Murex*. Lacaze-Duthiers observed a fisherman off the coast of Italy painting his shirt with the yellow juice of a freshly broken snail and saw that the stain soon turned a reddish-purple color. Lacaze-Duthiers identified the snail as a *Murex*. Through subsequent study, he determined that three mollusks in the *Murex* family—*Murex trunculus*, *Murex brandaris* and *Purpura hemastoma*—were capable of producing the purple dyes that had fetched such a high price in antiquity.¹⁴

Archaeology bears out Lacaze-Duthiers’s discovery. Remains of dye works containing enormous accumulations of crushed *Murex* shells have been found in the Phoenician cities of Tyre, Sidon and Sarepta, in Lebanon; Dor, Tel Mor, Shiqmona, Akko and Tel Keisan, in Israel; and Carthage, the Phoenicians’ most important colony.¹⁵ (In Virgil’s *Aeneid*—Aeneas languishes with Dido in Carthage, adorned in Tyrean purple robes.)

In Greco-Roman times, the importance of the *Murex* to the city of Tyre was reflected in the city’s coins, many of which bear an image of the snail.¹⁶ Others show a dog and a snail: According to legend, the purple dye was first discovered by Hercules’s dog, who was frolicking in the waves, foraging for food; when he emerged from the ocean and returned to his master, his lips were colored bright purple from the snails he had consumed.¹⁷

So, the Talmud locates the manufacture of *tekhelet* in the very place that both classical texts and archaeology tell us purple was created: on the northern coast of Israel (and Lebanon). And the Talmud identifies the source of *tekhelet* as *chilazon*, a snail. Could it be that the two colors actually came from the same animal?

A chance discovery made by Otto Elsner of the Shenkar Institute of Engineering and Design in Tel Aviv suggests this is the case. Elsner was trying to produce some purple wool by using the dye extracted from the hypobranchial gland of the *Murex* snail, but accidentally turned the wool blue instead.

The dye obtained from the *Murex* is called dibromoindigo; it consists of a molecule of the blue dye indigo with two bromine atoms attached to it. When it is first removed from the snail, it is yellowish, but when it is exposed to the air for five to ten minutes, it becomes purple. The molecule is capable of forming a chemical bond with wool, which is what makes it a permanent color that won’t wash out. To create a permanent bond, several chemical reactions must take place. First, limestone or another base must be added to water to create a basic solution. Next, the solution must be reduced—meaning that the oxygen must be removed, using a chemical such as ammonia (Pliny recommended using old urine, which contains ammonia). This causes the dye to dissolve and the solution to turn a darkish

yellow-brown color. At this point, the dye is ready. Wool dipped in the solution will remain white until it is pulled out and re-oxygenated through contact with air. It is striking to see: A purple color seems to magically appear on the material before your eyes!

Elsner was following these very steps one sunny day 30 years ago. But instead of immediately dipping the wool into the yellow solution, he left the dye sitting in the sunshine for a few minutes before dunking wool into it. When he finally pulled the wool out and waited for the usual purple color to appear, he was amazed to see the wool change to a vibrant blue instead.

Elsner’s chance discovery has shown us the most likely recipe for biblical blue. The secret ingredient is the sun! Unbeknownst to Elsner—or anyone else at that time—the dibromoindigo (purple dye) solution is affected by the sun’s radiation. Sunlight causes the bond between the bromine atoms and the indigo molecule to break down, leaving only indigo—blue dye—active in the solution. (The chemical indigo derived from exposing the purple dye to sunlight is in fact chemically identical to the indigo produced by the *kala ilan* plant. No wonder the rabbis had trouble telling them apart!) Depending on the amount of sunlight the dye is exposed to, the secretions of the *Murex* snail can produce a range of colors from red to royal purple to blue.

Thanks to Elsner’s discovery, the ancient biblical process has been rediscovered, and thousands of people around the globe now wear *tekhelet*-dyed *tzitzit* on their prayer shawls, just as Jews did in ancient times. After our dive about a decade ago, my colleagues and I founded the nonprofit P’til Tekhelet foundation, which harvests *Murex* snails to make the dye to manufacture *tzitzit*. (About 30 snails are needed for one set of *tzitzit* strings. We harvest thousands every year!) The success of the reinstatement of *tekhelet* breathes new life into the verse “and the triple spun thread shall not easily be broken” (Ecclesiastes 4:12). BR

For more information on the P’til Tekhelet foundation, visit their Web site, www.tekhelet.com.

¹ F. Thureau-Dangin, “Un comptoir de laine poupre à Ugarit d’après une tablette de Ras-Shamra,” *Syria* 15 (1934), pp. 137-146.

² Personal communication with Dr. Irving Finkel, Department of Western Asiatic Antiquities, British Museum.

³ Babylonian Talmud, *Sota* 46b.

⁴ Babylonian Talmud, *Shabbat* 26a.

⁵ Babylonian Talmud, *Baba Metzia* 61b.

⁶ Babylonian Talmud, *Menachot*.

⁷ *Responsa of the Radbaz*.

⁸ *Sepher Ha Chinuch*, Commandments of the Tzitzit.

⁹ Isaac Halevi Herzog, *Hebrew Porphyrology* (Jerusalem: Keter, 1987), p. 114.

¹⁰ Herzog, *Porphyrology*. Herzog concluded *Janthina* was the best option when he found that the *Murex* only gave a purple color and that the color

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