Since the dawn of civilization, silver and gold have been treasured for their surpassing beauty and captivating luster. Some of the earliest known gold jewelry, dating from approximately 4500 BC, was found in a cemetery in Varna, Bulgaria, on the west coast of the Black Sea (Gimbutas 1977). Precious metals have been used for currency around the Mediterranean since at least the third millennium BC (Balmuth 1975), and the oldest preserved coins are hand-stamped staters from Anatolia (western Turkey, about 600 BC) made of electrum, a natural alloy of silver and gold (Wallace 1987). Throughout history and around the globe, gold and silver have been mined, refined, and fashioned into nearly every kind of object imaginable. But perhaps some of the most intriguing examples of these beloved metals are those whose stunning and graceful forms cannot be attributed to the hand of man.

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**Figure 1.** Section cut through a wire silver from Kazakhstan shows roughly equigranular texture as opposed to a bundle of whiskers or a single crystal. From Anderson et al. (2017).

**Figure 2.** SEM image of a synthetic wire silver shows striations superimposed on a roughly equigranular texture. From Anderson et al. (2017).
Figure 3. Wire silver, 21.6 cm tall, from Kongsberg, Norway. Cranbrook Institute of Science specimen, Jeff Scovil photo.
Figure 4. Wire gold, 11.7 cm tall, from the Ground Hog mine, Gillman district, Eagle County, Colorado. Harvard Mineralogical and Geological Museum specimen, Jeff Scovil photo.
The wire form is an unusual and relatively rare mineral habit characterized by elongate hairlike growths with longitudinally parallel striations and wiry, twisting, sometimes contorted, tendrils. Anderson et al. (2017, p. 11) published the first study on the crystallinity and texture of wire silver. They found that although silver wires might appear to be single crystals or polycrystalline bundles of whisker-shaped crystals, they are actually polycrystalline with striations “merely superimposed on an equigranular grain texture” (figs. 1 and 2). Very few minerals assume the wire habit, the most prominent of which are the illustrious silver and gold. In this Connoisseur’s Choice column we highlight examples of both wire silver and wire gold.

Wire Silver

Silver is a highly malleable and ductile metal with a brilliant white luster, a result of its excellent reflectance across the entire visible spectrum. It has a hackly fracture and is relatively soft with a Mohs hardness of 2.5–3; a specific gravity of 10.5 imparts a pleasing heft to it. Silver is diamagnetic and has the highest electrical conductivity of any metal but is generally too expensive for use in wiring, and its propensity for oxidizing (tarnishing) prevents it from being employed in electrical contacts, as gold is often used. One historic application of silver has been in photography in the form of silver halide film. Native silver crystallizes as isometric (hexoctahedral class) crystals and can be found in a variety of habits including massive, reticulated, dendritic, arborescent, and, of course, wire habits (e.g., Wallace, Barton, and Wilson 1994; Cook 2003).

Our Connoisseur’s Choice for wire silver, standing 21.6 cm tall, is an impressive specimen from the mineral collection of the Cranbrook Institute of Science in Bloomfield Hills, Michigan. It was purchased from Martin Ehrmann by the Cranbrook Institute of Science in 1963 with money from the Goddard Fund (see Zawiskie 2017). It is arguably the best and certainly the largest example of Kongsberg wire silver in the United States (fig. 3).

Figure 5. Wire silver with calcite, 7 cm tall, from Kongsberg, Norway. Dave Bunk Minerals specimen, Jeff Scovil photo.

Officially discovered in 1623, the mines of Kongsberg, Norway, were a historic source of silver specimens for more than 330 years. Located some 80 kilometers west-southwest of the capital city of Oslo, Kongsberg hosts approximately three hundred mines that collectively produced an estimated 43 million troy ounces of silver before they closed in 1957. The veins are hosted in various Precambrian gneisses and amphibolites with abundant fahlbands (narrow zones rich in sulfide minerals) cut by Permian diabase dikes. It is significant that “silver only occurs where the [calcite-bearing] veins cut the fahlbands . . . the two most important examples [of which] are the Overberget and the Underberget fahlbands” (Johnsen 1986, p. 26). In these intersections, thick, hearty, and coarse trådølv (literally “thread silver”) are common occurrences (fig. 5), along with crystalline silver, abundant calcite, and other gangue minerals including acanthite, graphite, pyrite, galena, and silver-antimony sulfosalts.

Although the formation of wire silver remains poorly understood despite centuries of synthesis experiments (Henckel and Stephani 1747; Häüy 1801; Liversidge 1877; Vogt 1899; Kohlschütter and Eydmann 1912), Jensen (1939) argues and demonstrates that the wire silver of Kongsberg likely formed by hydrothermal processes. His hypothesis is consistent with the generally accepted idea that the Kongsberg silver deposits are probably synchronous with the Permian Oslo Rift (Johnsen 1986) and that the silver likely migrated in hydrothermal fluids from nearby black shales (Brandes and Brandes 2015). At Kongsberg, wire silver is frequently found on various gangue minerals including pyrite, galena, and calcite (Neumann 1944).

Although the Kongsberg mines may have been the most significant in terms of native silver production, the Freiberg mining district of Saxony, Germany, is far older and equally famous. Established around AD 1168, some four and a half centuries earlier than Kongsberg, German mines produced some of the world’s finest silver for more than eight hundred years. It was in fact German miners (of the Harz district), because of their already historic experience, who were first brought in by the king of Denmark-Norway to work the mines in Kongsberg (Johnsen 1986).
The Freiberg mining district is a network of veins hosted in the crystalline basement rocks of the Erzgebirge ("Ore Mountains"), a complex of gneisses, schists, amphibolites, and igneous intrusions, much like that of Kongsberg. The native silver is most concentrated where silver veins cross-cut sulfide-rich veins (Massanek, Neumeier, and Sandmann 2015). Although wire silver (haarsilber in German) can be found throughout the Erzgebirge, including mines in Johanngeorgenstadt, St. Joachimsthal, Annaberg, and Marienberg, the most famous and characteristic wire silvers are associated with Freiberg (fig. 6) and, to a lesser degree, Schneeberg (Lieber and Leyerzapf 1986). The Himmelsfürst mine in the Freiberg district, for example, has produced many museum-quality specimens exceeding 10 cm in length. St. Andreasberg, a mine in the Harz Mountains that has yielded some very fine heavy silver wires, also deserves an honorable mention.

Typical Freiberg silvers are more slender and wiry, and more often associated with acanthite, than those from Kongsberg. Other important minerals from this deposit include galena, sphalerite, silver sulfosalts, barite, pyrite, chalcopyrite, fluorite, siderite, quartz, and calcite, although the latter two are rarely found together (Massanek, Neumeier, and Sandmann 2015). As at Kongsberg, it is unclear how these wires form. There has been no shortage of German scientists who have attempted to unveil the mechanism behind this phenomenon (Bischof 1843; Opificius 1888; Friedrich and Leroux 1906; Kohlschütter and Eydmann 1912; Blaha 1957; Vogt 1899), but a cohesive explanation remains lacking. Further research will be necessary to solve this centuries-long mystery.

In addition to Kongsberg and Freiberg, other localities have produced excellent wire silvers.

Mining in the Imiter district, located in the heart of Morocco, can be traced as far back as the eighth century AD. Although it was largely abandoned by the fourteenth century, it was "rediscovered" in the 1950s and since has become one of the world’s foremost silver mines (Barral, Favreau, and Lheur 2011) still producing beautiful specimens of wire silver and acanthite (fig. 7).

In China, the Hongda mine in the Shanxi Province has yielded some very nice silver wires in recent years (fig. 8),
although they tend to be smaller and less spectacular than those from Kongsberg and Freiberg. Also, Tongchong, Yunnan Province, and Lujiang, Anhui Province, are home to some stunning pieces.

The Dzhezkazgan mine in Kazakhstan, about 30 kilometers northwest of Zhezkazgan in the Karagandy Province, has produced some amazing specimens, often in mesmerizing tangled masses (fig. 9). This locality also contains fine examples of chalcocite and rare copper minerals including bornite, betekhtinite, and likasite.

The Silver Islet mine in Ontario, Canada, mined extensively from the 1870s to 1970s, produced some exceptional specimens, several of which are now on display in the Royal Ontario Museum (fig. 10). Silver Islet wire silvers tend to be fairly thick, somewhat resembling those of Kongsberg (Wilson 1986). Also, the Highland Bell mine in Beaverdell, British Columbia, has yielded many wire silvers, often associated (and sometimes encrusted) with acanthite (Ingelson and Mussieux 1989).

Museum-quality examples of wire silver from the United States are comparatively few. Although wires have been found infrequently in many places, especially in the western states, arguably the best specimens have come from the Bulldog mine, in Mineral County, Colorado (fig. 11).
Mexico’s most important source of wire silver is the Batopilas district in southwest Chihuahua (fig. 12). Between the mid-seventeenth and twentieth centuries, it is estimated to have produced as much as 300 million troy ounces of silver, approximately seven times that of the legendary Kongsberg (Wilson and Panczner 1986). Productive mines in Zacatecas and Guanajuato (fig. 13) have also generated many collectible wires, although they are generally smaller.

Peruvian silvers, especially those from the Uchucchacua mine (fig. 14), have recently captured the attention of many collectors. This remote location is in the central Andes Mountains approximately 160 kilometers north-northwest of Lima. Cook (2003) has already highlighted some of the best wires from Uchucchacua and provided a good overview of other wire silver occurrences around the world.

**Wire Gold**

Gold, like silver, is a familiar soft (Mohs 2.5–3), malleable, ductile metal with a characteristic bright yellow luster. Although similar to silver in many ways, gold is nearly twice as dense (specific gravity of 19.3) and up to eighteen times less abundant in Earth’s crust. Its radiant color and its resistance to corrosion or oxidation have made it the object of human desire since time immemorial. Thus, gold is currently, and historically, far more valuable per ounce than silver. It is the

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**Figure 12** (left). Wire silver, 9.8 cm tall, from the Batopilas district, Chihuahua, Mexico. Former Miguel Romero specimen, Jeff Scovil photo.

**Figure 13** (right). Wire silver on polybasite, 5 cm tall, from Guanajuato, Mexico. Albert and Sue Liebetrau specimen, Jeff Scovil photo.

**Figure 14.** Wire silver, 5.1 cm tall, from the Uchucchacua mine, Lima Department, Peru. Carnegie Museum of Natural History specimen, Debra Wilson photo.
third most conductive metal behind silver and copper, highly resistant to corrosion, and chemically inert with respect to living tissue, making gold an excellent metal for jewelry. In minute quantities it is an excellent and dependable material for both high-efficiency electronics and sensitive medical applications. Again, like silver, gold crystallizes in the same isometric system (hexoctahedral class) and can be found in many of the same morphologies, including wires.

Virtually no data concerning the crystallinity of wire gold has been published. Collectors are understandably averse to subjecting their rare treasures to potentially damaging tests, and researchers have historically fixated on the formation of their magnitudes-more-abundant and less expensive cousin, wire silver, with few exceptions (Liversidge 1877; Beutell 1919). However, because of the unmistakable similarities between wire gold and silver, it is possible that many of the observations made of wire silver by Anderson et al. (2017) will be found to apply to wire gold as well.

Nevertheless, wire gold also possesses some distinct differences when compared to wire silver. For instance, the striations, which are so striking in silver, are usually poorly expressed in gold. This can be accounted for in a number of ways. First of all, the term gold wire has been used rather loosely among mineral collectors for any gold crystals resembling drawn-out and/or bent shapes. Upon close examination, however, many of these specimens appear to be more dendritic or ribbonlike and, in some cases, elongate hoppered octahedral or spinel-law twins. Perhaps these “pseudowires” are not true wires at all (Mauthner 2004). Another case might be those found as placer gold, whose striations may simply have been eroded away during transport. A third consideration was raised by Beutell (1919), who attempted to grow wire gold in the same way he had grown wire silver but was unsuccessful. In his experiments, gold wires formed only when the gold was argentiferous. It is true that many of the best-developed gold wires possess an electrum-esque color, and it is possible that these could contain an appreciable amount of silver.

Because wires are rarely well-developed and a rare habit of gold, our Connoisseur’s Choice for wire gold, at 11.7 cm long, 1.9 cm thick, and weighing 8.5 ounces, may just be their king (fig. 4). This magnificent wire gold, named “the Gold Horn,” was collected in 1887 from the Ground Hog mine in Gilman, Colorado. However, the identity of the specimen’s locality had been lost until recently when, as Raines and Francis (2008, p. 223) describe, it was rediscovered:

When acquired in 1948 as part of the Burrage collection, it was labeled “California,” as so many gold specimens are. Fortunately, the Ground Hog mine ore . . . was so unusual that it was described in both the scientific (Argall 1893) and popular press (Anonymous 1893). Because the Horn is illustrated in both articles, both its locality and early provenance were rediscovered. Argall opines that it “is beyond doubt, one of the finest gold specimens ever discovered.”

When economic ore deposits were discovered in the Gilman district in about 1879, it became Colorado’s most important source of zinc as well as a rich producer of lead, copper, silver, and gold (Lovering, Tweto, and Lovering 1978). “Between 1884 and 1925, rich gold ores were mined from the oxidized, up-dip portion of several manto-replacement deposits in the Sawatch Quartzite, with the highest grade ores in the district being found in the Ground Hog mine” (Warren and Pedersen 2003, p. 304). The chimney veins of the Ground Hog mine have produced amazing specimens of wire gold. Large and robust with deep striations, they are perhaps the best in the world.

Gold wires from the Ground Hog mine are rivaled only by those from Venezuela. Santa Elena de Uairen, in the Bolivar Province, has produced some superb gold wires in recent years. A marvelous specimen housed in the Treasures
Room of the MIM Museum in Beirut, Lebanon, measures 12 cm tall, although the wire would undoubtedly measure longer if uncoiled (fig. 15). Little information is available concerning the geological setting of these deposits except for the general stratigraphy: Roraima Supergroup (Paleoproterozoic sedimentary) and Precambrian basement complex cut by gabbroic intrusions and overlain by quaternary alluvial sediments (López, Mencher, and Brineman 1942; Santos et al. 2003). Some of the most productive sites are those where the local rock has been weathered to soft clay. Two other important South American localities for fine wire gold samples are the San Juan Basin, Municipio de Novita, Chocó Department, Colombia, and the Julcani mine, Huancavelica Department, Peru.

Unlike with wire silver, the United States has been the source of many of the best examples of wire gold. The Wire Patch mine, Breckenridge, Colorado, just 30 kilometers east of Gilman, is famous for its “nests” of gold wires (fig. 16), although they often straddle the line between wires and either dendrites or perhaps highly elongate spinel-law twin crystals. One wire from Eldorado County, California, possesses strong striations and is 5.7 cm long (fig. 17). The Mad Mutha mine, Humboldt County, and the Olinghouse district, Washoe County, Nevada, along with the San Pedro mine, Santa Fe County, New Mexico, have produced wirelike specimens, but many of these are better described as pseudowires rather than as true gold wires.

While Asia is not typically known for producing wire gold, the Cansuran mining district in the heart of the Surigao Peninsula, Mindanao, Philippines, may be an exception. Although little information is available about the specific location or geologic setting of these deposits, crystalline gold has been historically common there—and in several mines as wire gold (Eddingfield 1911). In addition, the Aroroy mining district, Masbate, Philippines, is home to some beautiful wires (fig. 17).

Many wires have been found as placer gold, perhaps the most impressive of which is “the Boomerang,” a 10.1-cm-long, 1.5-cm-thick wire found near Butte Creek, approximately 13 kilometers east of Butte Meadows, California (fig. 18). Some smaller specimens have come out of the Little Blanche Creek, Thistle Creek, and Freegold areas of the Yu-
kon (Mauthner 2004) as well as various (and poorly documented) locations in Alaska.

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REFERENCES
