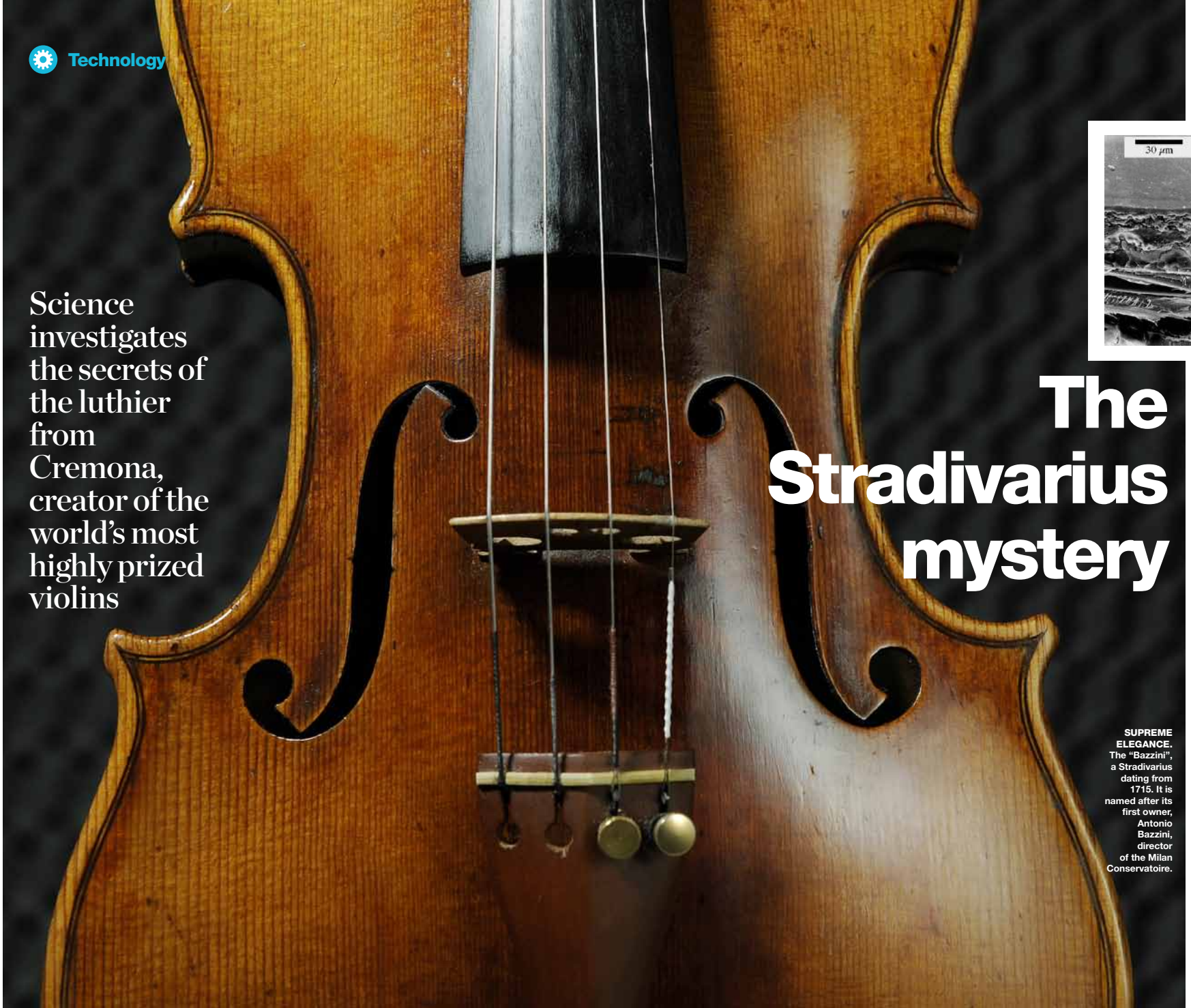
The Stradivarius mystery

Science investigates the secrets of the luthier from Cremona, creator of the world's most highly prized violins



Roberto Caccuri/Contrasto

SUPREME ELEGANCE. The "Bazzini", a Stradivarius dating from 1715. It is named after its first owner, Antonio Bazzini, director of the Milan Conservatoire.

UNDER THE MICROSCOPE. Magnification of the surface layer of varnish (0.03mm) of a cello made by Pieter Rombouts, a contemporary of Antonio Stradivari.

Gent. conc. C.Y. Barlow e J. Woodhouse, Cambridge University.

The maestro would wander round the Val di Fiemme woods with a torch, when the moon was full. One by one, he would scrutinise the spruces (Picea excelsa). Finding a majestic specimen, he would remove a piece of bark, strike the tree with a hammer and listen. If he liked the sound, the tree would be felled and transported to Cremona...

We do not know if this is how Antonio Stradivari really selected the wood for his violins. What we do know is that, four centuries later, they are still world renowned for their limpid, luminous and richly nuanced sound. The most celebrated violinists, such as Uto Ughi, compare them with Raphael paintings "for their balance and purity".

But how exactly did Stradivari impart a soul to the wood? Did he use special materials, adopt a secret process? Countless stringed-instrument makers have tried in vain to replicate his violins. And, over the last 80 years, physicists and chemists in different parts of the world have tried to discover his secrets, studying the instruments using X-rays, CT scans and spectroscopic techniques. These have yielded some interesting results, but many uncertainties remain.

MISSION IMPOSSIBILE. It is, in any case, an almost impossible challenge: Stradivari did not leave any documents describing his methods, knowledge of which was lost for ever in 1743, when his sons Francesco and Omobono, his only apprentices, died just six years after the master himself. Futhermore – and this is a serious limitation for a researcher – it is not possible to scrape so much as a molecule from one of these instruments, given their historical, musical and financial value: in 2011, the 'Lady Blunt', a Stradivarius dating from 1721, sold for 11.1 million € (over 12 million $).

Their legendary sound? A combination of painstaking design, the very best materials and special processes

AN INIMITABLE SHAPE. The 'Bazzini' in profile and (right) its scroll: it was made during Stradivari's golden period. The kinds of wood used and the inlay decoration depended on how much the customer was prepared to pay.

'Strads' have in fact become an investment: the prices they sell for have increased 200-fold over the last 20 years, 10 times more than gold. This is why many of the surviving violins belong to Russian, American and Japanese millionaires, not to mention financial institutions. Matteo Fedeli, the violinist who has played the largest number of these instruments - 25 in the last 11 years – goes around with armed bodyguards and expensive insurance policies when he performs with the 'Bazzini' (1715), owned by a Swiss collector. "Many of the owners of these legendary violins are not able to play them", he says, "so they contact me to keep them alive by playing them in a concert setting."

GOLDEN PERIOD. Stradivarius violins, together with the Gutenberg Bible and Leonardo's Mona Lisa, are icons of Western culture. This is why, in the last century, Lenin and Hitler were so quick to confiscate them. But they were already a legend during the lifetime of their maker, who died in Cremona in 1737, at the age of 93. His instruments – harps, lutes and mandolins, as well as violins and violas – were sought after by popes and rulers from all over Europe.
Stradivari had succeeded in perfecting the violin, an instrument developed in the workshop of his fellow townsman Andrea Amati at the end of the 16th century. Until 1679, the young man had served as an apprentice in the workshop of Amati's nephew, Niccolò. In 1680, he set up on his own account and in the next 57 years built no fewer than 1,116 musical instruments - a rate of around 20 a year. Just over half have survived, 650, of which 500 are violins. The most highly valued are those of his 'golden period', produced between 1700 and 1720.

GOLDEN FLAME. According to Fedeli, "Their distinguishing features are their golden, flame-like varnish; the carefully cut-out "f"-holes in the sound box, their curvature and scrolls. In some cases, the label glued to the inside of the instrument: Antonius Stradivarius cremonensis faciebat. And, obviously, their unmistakeable sound. Each has its own personality, which is why they bear a name, the name of their original owner."
But to what can their unique sound be ascribed? Research has pointed to three factors: painstaking design, the timber used, and the way in which the timber was treated. "Stradivari", according to Fausto Cacciatori, curator of the Cremona Violin Museum, "would make careful drawings of his violins on paper, before cutting out the wooden shapes. He drew on his wealth of experience and a long tradition, but he was also in close touch with contemporary violinists. He was successful because the violins he built were not only beautiful and harmonious, but also had a powerful 'voice', which was increasingly important in the making of late-Baroque music." And the same is true today: "When I do half a day's practice", explains Fedeli, "I have to use ear-plugs, or I am bound to end up with headache". The sound of a strad is a force to be reckoned with.

ICE AGE. A violin is made up of 70 different parts. For the body of the violin, which acts as a sound box, Stradivari used two kinds of wood: Balkan maple (Acer hyrcanum), lighter and more rigid than its Italian counterpart, for the back; Alpine spruce for the belly, or top. We do not know where he got his supplies: studies of the timber he used suggest that he purchased whole tree-trunks, probably from the woods of the Trentino region. Once felled, they were shipped along the River Po to Cremona. He then left them to season on the *secadùur*, the covered terrace of his workshop. According to Lloyd Burckle, a geochemist at Columbia University, Stradivari was favoured in his selection of timbers by a chance climatic factor: the trees he used were survivors of the Little Ice Age, a period of severe winters which affected Europe in the years 1645 to 1715 and slowed the trees' rate of growth, producing a compact, elastic timber with evenly proportioned rings.

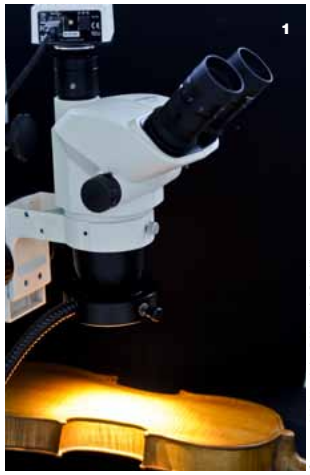
11,1
million € (over 12 million $): the highest figure ever paid for a Stradivarius (the 'Lady Blunt', 1721), in 2011.

VARNISHES. Finally, there are the varnishes Stradivari used to embellish and protect his violins. Rivers of ink have flowed on this subject. Without these 50 microns (thousandths of a millimetre) of varnish, strads would make a much poorer sound. So what exactly did the maestro use? The only documentary evidence we have is a letter in which he apologises for late delivery of an instrument, due to the time required for the varnish to dry: "You will bear with me if the violin is delayed because of the varnish, so that the sun does not open up any big cracks". In the 1970, Simone Sacconi, a luthier who in the course of his career restored 350 strads, suggested that the varnish was used to improve the sound quality of the wood: "Stradivari prepared a vitreous substance which made the wood harden and become more homogeneous as it penetrated into the pores in the timber. Thin though the wood was, this increased its capacity to vibrate and produce a more powerful sound." According to Sac- ▸

Roberto Cacciuri/Contrasto (2)

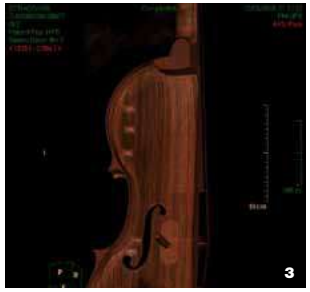
"For balance and sound purity, they are like Raphael's paintings"
Uto Ughi, violinist

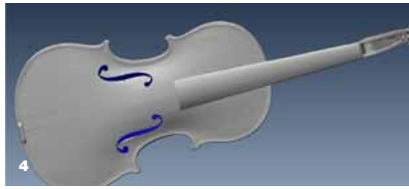
SCIENTIFIC RESEARCH. Gli studi non invasivi sugli
Non-invasive studies of Stradivarius violins
1. An old instrument under the stereomicroscope: showing small scratches.
2. A violin lit by an ultra-violet fluorescent lamp: the darkest areas are those where the varnish is thickest.



Gent. concessione Matteo Fedeli (2)

Gent. conc. del Laboratorio Arvedi, Università di Pavia (2)





INITIAL RESULTS. Results of the investigations
3. A TC scan: the small rectangles on the body show where the wood has been repaired (with filler).
4. Three-dimensional model of a Stradivarius, used for replicating the various shapes.

OF 650 INSTRUMENTS, ONLY ONE IS ALMOST 100% ORIGINAL

ALTERATIONS. Over four centuries, Stradivarius violins have inevitably undergone alterations. The wooden parts have been filled and revarnished, and various components have been replaced without undue reverence. The important thing was that they could be played. In the 19th century, for example, all violin fingerboards were replaced with longer, more angled versions so they could play higher notes.
Of ther 650 instruments that have come down to us, the only Stradivarius still in original condition (including varnish), is the 'tenore mediceo', a 1690 viola on display at the Galleria dell'Accademia in Florence. Because of its large size, it has been little played over the years. And yet, nobody, according to the Florentine luthier Fabio Chiar, has really studied it, though some X-rays and UV photographs have been taken. More searching investigations could reveal the secrets of Stradivari's varnishes.

After Stradivari's death, his 'recipe' was lost. Luthiers adopted 'Chinese' varnishes, easier to use for producing more violins.

"To the refinement of his instruments, Stradivari adds nobility, embellishing them with graceful purfling"

Desiderio Arisi, friend of Stradivari.

Gent. conc. Laboratorio di Acustica Musicale, Politecnico di Milano (2).

RECORDINGS. Violinist Anastasiya Petrishak playing the 'Vesuvius' in order to record its acoustic properties; above, a bow fitted with a movement-monitoring system for studying the interaction between musician and instrument.

An unmistakeable sound? Not according to scientific testing...

A SURPRISING RESULT. Not so unmistakeable after all. A French researcher studying acoustics, Claudia Fritz (Institut Jean Le Rond D'Alembert, Paris), has put the Stradivarius legend to the test. In 2012, she invited ten famous soloists to a concert hall in Paris, blindfolded them and presented them with 12 violins, 6 ancient (including five strads) and 6 modern. They each played for two 75-minute sessions, solo and accompanied by an orchestra. Result: six out of ten preferred a modern instrument. The one that got the most votes overall was a modern instrument, while a Stradivarius from the golden period came only third.

Can one generalise from the judgement of 10 musicians? "Probably not", replies Fedeli. "A couple of hours is not enough to form a relationship with an antique instrument. Especially since the sound of a violin needs to be judged from a distance. The performer himself is too close to the source to assess it effectively." Indeed, Claudia Fritz also asked 50 experts present in the concert hall to say which of the 12 violins sounded best.

The jury is still out: the results will be published in 2015. The mystery remains unresolved.

FULL IMMERSION. The Milanese violinist Matteo Fedeli – the musician who has played the greatest number of strads: 25 in the last 11 years.

Roberto Caiozzi/Contrasto (2)

coni, Stradivari used silica, carbon and potash, the ash produced by burning the dregs from the grape press. These ingredients were reduced to a powder, dissolved in water, boiled again and then decanted. Spread on the wood, the varnish took weeks, if not months, to dry. Some researchers from Cambridge University, have hypothesised that he used volcanic ash.

X-RAY ANALYSIS. To get a better understanding, researchers at the University of Pavia's Arvedi Laboratory, inaugurated in 2013 at the Cremona Violin Museum, have been using scene-of-crime techniques. They first shone an ultra-violet fluorescent lamp on the Museum's violins to identify the areas with the thickest covering of varnish. Using radiography, they pinpointed the least restored areas, then investigated them with spectroscopic techniques to identify the molecules contained in the wood, based on how they absorb light.

The result? "We have found calcium and potassium", reveals Marco Malagodi, lecturer in restoration chemistry at the University of Pavia. "It is probable that Stradivari treated his violins with a mixture of casein (a milk protein) and slaked lime (calcium hydroxide). After a week, this yields calcium caseinate, a glue. This substance has been found in other instruments by Austrian researchers". Stradivari followed this up with two further layers: "an insulator, made of linseed or walnut oil and pine resin (rosin); and a layer of coloured varnish consisting of oil, rosin and, in some cases, cinnabar, a mineral rich in sulphur and mercury that Leonardo da Vinci had previously used as a red pigment. These varnishes took many weeks to dry." This also explains why Stradivari produced fewer than two instruments a month.

SHARP EYES, SKILLED HANDS. No alchemist's magic, then? "The techniques and materials employed by Stradivari were the same as those used by his contemporaries", comments Bruce Tai, a chemist at the California Institute of Technology. "He obtained his supplies from vendecolori, pharmacists who sold pigments for painters and furniture-makers. But the processes he adopted were complex, with many variable parameters (dosage of the mineral particles, type and quantity of rosins and pigments, heating and drying times). Using the same ingredients, luthiers could obtain very different results. Stradivari's success depended on a combination of sharp eyesight, acute hearing, manual dexterity, attention to detail, creativity through constant tweaking, and, most of all, artistic inclination. Augusto Sarti, director of the Musical Acoustics Laboratory at the Polytechnic of Milan, is trying to identify the physical parameters typical of the Stradivarius sound, whatever they may have been. "Our objective", he says, "it to replicate them in modern instruments."

650

The number of Strads that have survived. Stradivari is reckoned to have made 1,116 instruments in 57 years.

CHINESE VARNISHES. The processes used by the luthier from Cremona were lost for ever after his workshop closed. At the end of the 18th century, oil-based varnishes were replaced by alcohol and essential oils. These were 'Chinese' varnishes, based on sandarac resin (obtained from a North-African tree) and shellac, a polymer derived from an Asiatic insect, the lac bug (Kerria lacca). Strong and shiny, cheap and easy to apply, they were ideally suited to the growing demand for violins in Europe.

Maybe the secret of Stradivarius violins was simply a question of slowness – like the heart-rending slowness of Oblivion, a piece by Astor Piazzola that Fedeli performed for this Focus reporter on the instrument dating from 1715. It brings tears to one's eyes. Whether this should be ascribed to the violinist or the elusive luthier is also a mystery. And maybe it is better it remain so.

Vito Tartamella