



Rings as Keys to the Past: A Case of Dendroarchaeology

by

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Part I – The Inheritance

The Theft

Fred and Ed were single, unmarried brothers and had started *Fred 'n Ed's Treasure Chest* pawn shop nearly 50 years earlier in Buffalo, New York's bohemian district. The day a violin became part of the store's inventory, Fred was sick at home and Ed had gone to the bank to make a deposit. Their one and only employee was left in charge of the shop and as he later recounted, "A woman came into the shop about 10 AM with a violin case. She was followed by a man wearing an overcoat and a red knit beanie, which I thought was strange since it was already 80°F with humidity to match. The woman came to the counter and after opening the case, gave me a handwritten bill of sale explaining that her grandmother had recently passed away leaving her, as an inheritance, this old violin. She had no use for it and wanted to sell it to the shop for whatever I was willing to give her. Because of its rough physical appearance, I told her I could only pay her \$50. After writing out a receipt and handing it to her, I opened the cash register..."

"The next thing I remember, I was lying on the floor behind the counter and my head really hurt! The cash register door was open and all of the paper money—about \$100—was gone! The woman with whom I had been talking was staring at the shop door and whimpering. When I asked her what happened, she said, 'The man who entered the shop behind me came from behind the shelves close to the register as soon as you opened it, hit you over the head with what looked like a gun, grabbed the money, and ran from the store!'"

Unfortunately, Fred died about a week later. Ed lost interest in the business, but rather than sell it to someone else, he told the bank to liquidate all the store's assets at auction. After paying off business and personal debts, he planned to retire to sunny, dry Arizona, but he died within a fortnight of Fred's death.

The Auction

It was so battered and scarred that the auctioneer figured it was a waste of time to even ask for bids for the old violin, but he held it up with the bow. "What am I bid, folks," he cried, "Who will start the bidding? A dollar, a dollar? OK! Two dollars... and who'll make it three? Three dollars! Three dollars, once! Three dollars, twice... SOLD to the gentleman in the back!"



Figure 1. Messiah Stradivarius.
Credit: Pruneau, CC BY-SA 3.0,
<https://commons.wikimedia.org/wiki/File:Messiah_Stradivarius.jpg>.

James was a collector; a collector of antiques, or at least of things that looked antique. James never bothered having any of his collectibles appraised as to their actual worth, but after retiring from 30 years as a city sanitation engineer, he loved attending auctions and estate sales to see “what types of old things people are selling...cheap.”

When he arrived home from the auction and opened the case, James was glad he hadn't paid more than \$3. As he looked at it, he was not sure whether to mount it on the wall over his fireplace or just put it on a large plate holder on the mantle.

A few days later, James had lunch with a friend who was fascinated by artifacts made of wood, particularly musical instruments. James told his friend Henri about his recent purchase and invited him to his home to see it. While James saw the violin only as an apparent antique, beneath the dirt and grime and with a practiced eye, Henri saw much more. He asked James if he could borrow the violin to fix a few broken strings, tune it, and clean it up. Since James was going out of town on business, he told Henri to keep it for as long as he liked.

Question

- Carefully examine panels (A), (B), and (C) of Figure 2 below. Based on your observations, what do the samples in the pictures have in common?

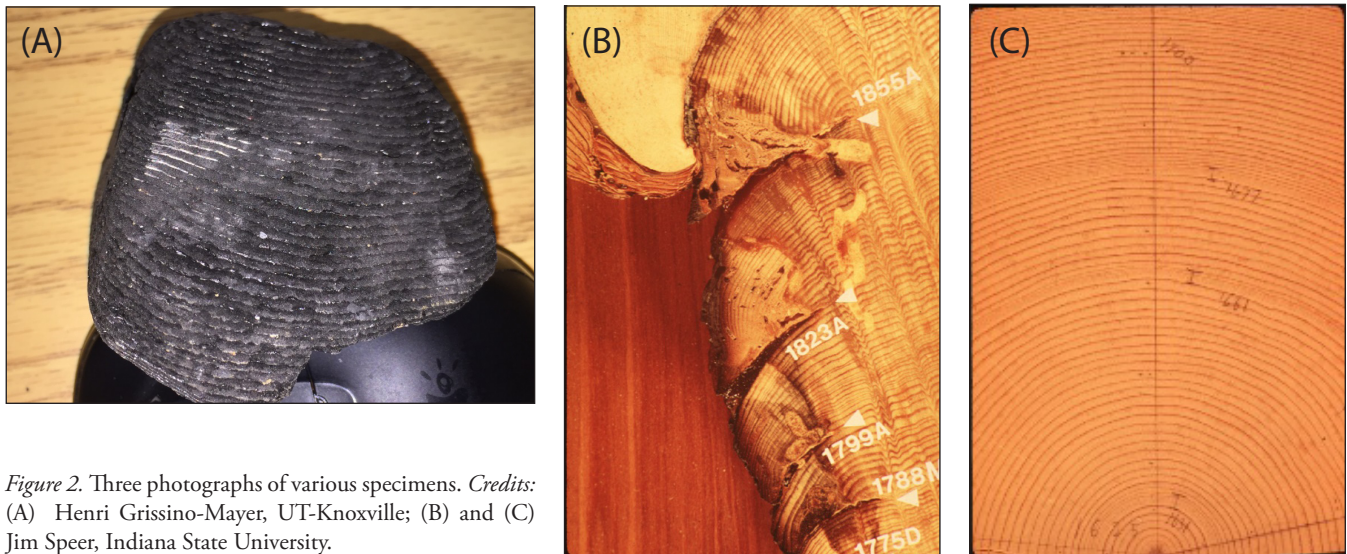


Figure 2. Three photographs of various specimens. Credits: (A) Henri Grissino-Mayer, UT-Knoxville; (B) and (C) Jim Speer, Indiana State University.

Part II – The Expert

Needless to say, Henri could not wait to get the violin “under the microscope.” He could tell from experience that the violin was an antique, but how old did a violin or any man-made item have to be for it to be considered a valuable antique? Henri was nearly consumed by his own curiosity.

Fortunately, James had allowed him to “borrow” the violin for as long as he wanted, which he hoped would give him time to complete his analysis. On account of Henri’s work as a professor of dendrochronology, he had all the necessary equipment for the analysis. He decided that until he knew exactly what he had—a genuine and valuable antique or one of more recent vintage—he would only handle the violin with gloves to prevent any more wear and tear.

Henri was familiar enough with the process of violin-making to know that the top of the violin is always used to determine a violin’s age. Violin “tops” are typically made from so-called “softwoods,” like spruce, while the neck, back, and ribs of the violin may be made from hardwoods, like maple.

When a violin top is added to the violin, the “grain” of the wood runs vertically (Figure 3A) and the cells that make up the wood are seen from the side rather than from the top, as shown in the view of an actual tree core in Figure 3B.

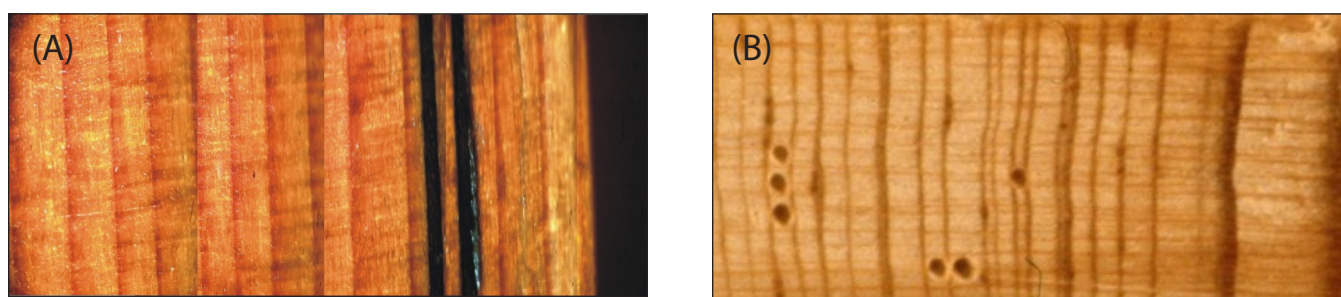


Figure 3. Wood grain from violin (A) and tree core (B). *Credit:* Henri Grissino-Mayer, UT-Knoxville.

As Figure 3A shows, when rings are viewed vertically, the boundaries between early and late wood are less distinct, and very narrow bands may be missed altogether.

Figure 4 below, shows the area (widest part) of any stringed instrument used by dendrochronologists to determine the age. Figure 5 shows Henri and the set-up he used to date James’ antique violin.



Figure 4. Lower bout, the widest part of a stringed instrument. *Credit:* Topham and McCormick, 1997.



Figure 5. Photo of Dr. Henri Grissino-Mayer, UT-Knoxville. *Credit:* Grissino-Mayer et al., 2002.

Part III – The Basics of Tree Anatomy

Before anyone can determine the age of something made of wood, there are a few important things to know about woody plants (trees) and how they grow. Like humans, trees grow in two directions—upward (height) and outward (diameter). Also, like humans, after reaching their genetically determined height, trees continue to grow outward until they die.

A woody tree stem or trunk in cross-section looks like the photograph below (Figure 6). Phloem cells are always found just beneath the bark of a tree. Phloem carries the “food” (sugar), made in the leaves via photosynthesis, to the roots. Xylem cells are always found on the inside of the phloem. These cells carry water absorbed through the roots upward to the leaves. Like humans, trees need water not only for photosynthesis, but for every other cellular process. Separating the phloem cells and the xylem cells is the vascular cambium, which cannot be seen in the photograph, but is labeled in Figure 7. The vascular cambium is the source from which both xylem and phloem cells are derived. The cells that form on the “inner” (pith) side of the cambium become xylem while the cells that form on the “outer” (bark) side become phloem.

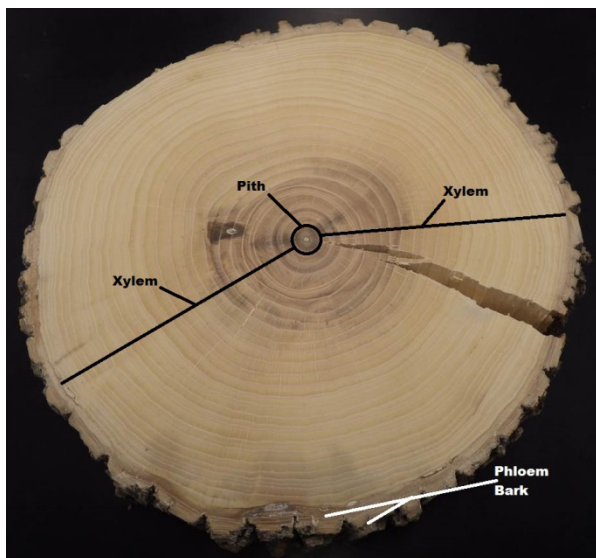


Figure 6. Tree in cross-section. Credit: Jim Speer, Indiana State University.

Question

1. Is the majority of the wood in trees and the rings that form from year to year xylem or phloem cells?

In closer view, Figure 8 (right) and Figure 9 (next page) show the difference in the rings that form in conifers, which means cone-bearing, and the wood from trees that produce flowers, e.g., sycamore, maple, oak, etc. Watch the following brief (3:37 min) YouTube video to better understand the difference between primary (height) and secondary (width) growth of trees: <<http://youtu.be/mbdur2TjTbk>>. The color difference between early wood and late wood is also explained. Next, watch <<http://youtu.be/PfplXfbrjuA>>; this 1:58 minute clip should help clarify the role of the vascular cambium, which is shown only as a thin black line in Figure 7.

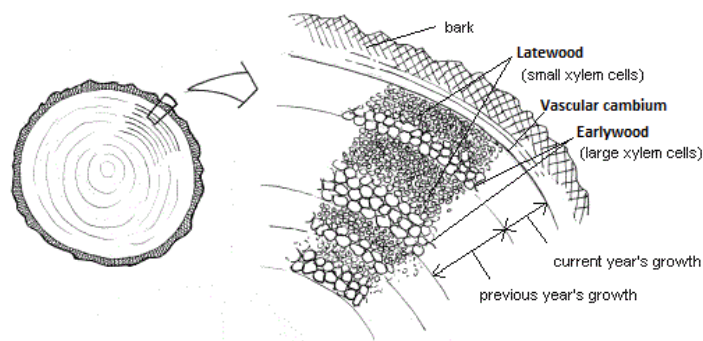


Figure 7. Tree in cross-section. Credit: National Gardening Association, <<https://garden.org/onlinecourse/PartI15.htm>>.

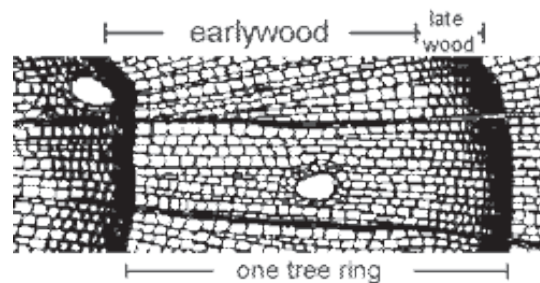


Figure 8. Conifer (gymnosperm) tree ring in transverse or cross-sectional view. The early wood appears lighter in color; the cells have thin walls and larger diameters. The late wood appears darker in color; the cells have thick walls and smaller diameter. Credit: Laboratory of Tree-Ring Research, University of Arizona, <<http://ltr.arizona.edu/>>.

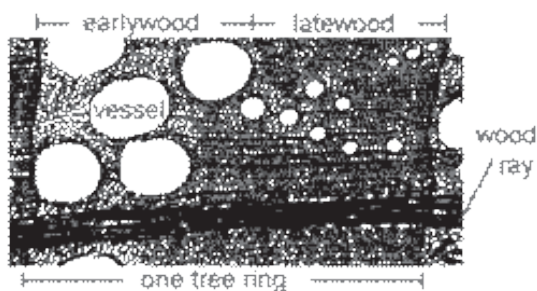


Figure 9. Flowering plant (angiosperm) tree ring in transverse or cross-sectional view. The early wood cells have large diameter “vessels.” The late wood cells have small diameter “vessels.” *Credit:* Laboratory of Tree-Ring Research, University of Arizona, <<http://ltrr.arizona.edu/>>.

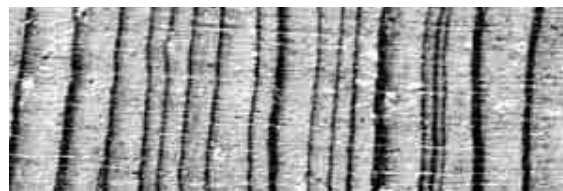


Figure 10. Variation in rings. This conifer wood sample shows that tree rings display great variation: variation in total ring width (light plus dark bands), variation in width of late wood (dark bands), and variation in late wood density (dark band contrast; some lighter, some darker). *Credit:* Laboratory of Tree-Ring Research, University of Arizona, <<http://ltrr.arizona.edu/>>.

Variation in the rings is due to fluctuating environmental conditions when the rings were formed. Studying these variations leads to improved understanding of past environmental conditions and is the basis for many research applications of dendrochronology.

With a basic knowledge of trees and the formation of a tree’s rings, you’re now ready to learn about two processes that are critical to the work of dendrochronologists: *skeleton plotting* and *crossdating*. No one can successfully determine the age of a tree or anything else made of wood unless these processes have been learned and practiced repeatedly. The exercises and graphics contained in Part IV will be used to practice and increase your understanding of these processes. The purpose of completing the exercises and reading the graphics is to gain a greater appreciation of the amount of time and effort necessary to date objects made from wood.

Part IV – Skeleton Plotting and Cross-Dating

Today, the use of technology has transformed learning in many ways. It has been shown that using virtual simulations of previously unknown processes and skills can speed up the actual learning of those processes and skills, as well as save time, money, resources, and even lives, as in the case of using simulators for pilot training.

To learn the beginnings of the process required to determine the age of wooden objects like James' violin, the following website—<<http://isu.indstate.edu/jspeer/dendro/>>— contains a number of virtual exercises. Once accessed, scroll down the page and click on the link: Crossdating Tree Rings. Complete the virtual “Try Skeleton Plotting for Yourself” activity several times to gain a basic understanding of the process. After completing this activity, the “hands-on” simulation that follows will make much more sense. *Note:* A Java-capable web browser must be used to access the features of this activity.

When finished with the virtual skeleton plotting exercise, read the instructions below and use the materials in the appendices to complete a hands-on, skeleton plotting simulation. This simulation has been designed with the non-science major in mind. It will help someone learn the process of skeleton plotting using a simplified simulation; but simplified does *not* mean *easy*. Please be patient with yourself and do not give up out of frustration. Nothing worth learning was ever learned well the first time, so give it the time needed to really learn how it's done.

Materials Needed and Instructions for Completing Skeleton-Plotting Activity

- Simulated “core” samples (Appendix 1)
- Graph paper for making skeleton plots of cores (Appendix 2)
- Master chronology (Appendices 3 and 4): An established chronology against which each “core's” skeleton plot will be compared and constructed. Each section of the master chronology will be cut into strips and then taped together to create one long master chronology strip.

Follow these steps:

1. *Before* cutting out the paper cores (Appendix 1), follow the directions written on that page and label each dot on the core with its correct “decade” (refer to Figure 11 at right).

Notes:

- The 1st core begins with yr. 0, the 2nd core begins at yr. 36, the 3rd core begins at yr. 74
 - There are no “micro,” “missing” or “false” rings in the simulated cores, as indicated in the right-hand diagram.
 - The preferred “tool” to use for writing on cores is a 0.7 mm mechanical pencil.
2. After identifying and labeling the decade years on each core, cut them off the paper. Appendix 2 contains strips of graph paper that can be cut out and used to make skeleton plots of the paper cores.

Note:

- If needed, review the virtual skeleton plotting activity link <<http://isu.indstate.edu/jspeer/dendro/>> and this link at pbs.org: <<http://www.pbs.org/wgbh/nova/vikings/treering5.html>>.

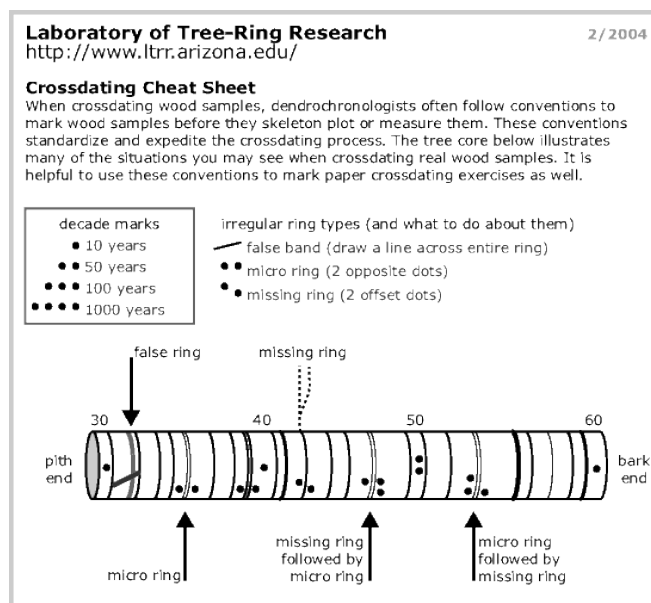


Figure 11. Diagram on crossdating. *Credit:* Laboratory of Tree-Ring Research, University of Arizona <<http://www.ltrr.arizona.edu/instruction/crossdating%20cheat%20sheet.gif>>.

3. Make a skeleton plot of each core sample brought to class using the strips of graph paper provided.
4. Cut out the master chronology strips provided (Appendices 3 and 4).
5. Tape each strip of the master chronology together end-to-end into one long strip, *with no gaps between the strips*.
6. Compare the lines drawn on the entire skeleton plot (graph paper strips) against the master chronology strand. Where the skeleton plot lines match exactly, or as close as possible, to a section of the master chronology strand, write the beginning and end-dates from the master chronology directly on the skeleton plot graph strips.

How Crossdating Is Used in Dendroarchaeology

Matching the patterns in ring widths or other ring characteristics (such as ring density patterns) among several tree-ring chronologies allows the identification of the exact year in which each tree ring was formed. For example, one can date the construction of a building, such as a barn or Indian pueblo, by matching the tree-ring patterns of wood taken from the buildings with tree-ring patterns from living trees. Crossdating is considered the fundamental principle of dendrochronology—without the precision given by crossdating, the dating of tree rings would be nothing more than simple ring counting.

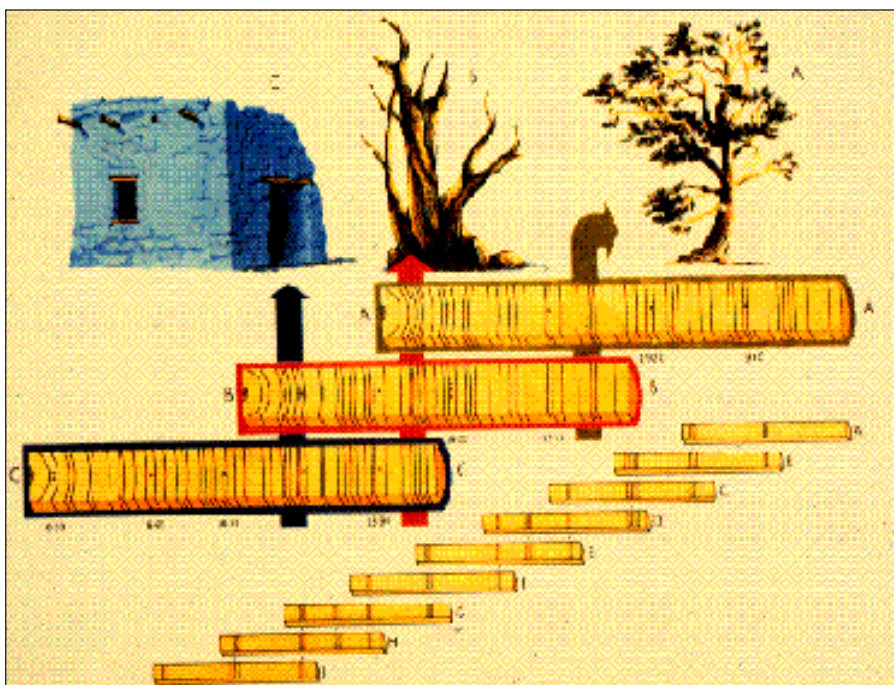


Figure 12. Diagram on crossdating. *Credit:* Henri Grissino-Mayer, UT-Knoxville.

Part V—The Rest of the Story

While many people think the primary job of a dendrochronologist is simply to “identify and count rings in wood,” that is only the beginning. After counting, *each* ring’s width must be measured to the nearest 0.001 mm. As the rings are measured, the measurements are entered into a computer program to use in the next step of the process.

To successfully determine the violin’s age, Henri still needed three things. First, he needed to know the source of the wood used to make the top of the violin. Second, once identified, he needed *reference (master) chronologies* containing the ages of the source wood. Without a master reference chronology, the “floating” (undated) chronology from the violin would be worthless. Third, Henri’s intuition and experience told him that James’ violin was not a one-hit wonder. In other words, whoever made James’ violin made more than one.

Luckily for Henri, diligent internet research paid off. He discovered that although James’ violin contained no identifying “maker’s tag,” when he posted digital pictures of the violin online, violin aficionados from all over the world recognized distinct characteristics. From the information received, he was able to discover that the wood for the top came from forests in the Italian Alps (Northern Italy). However, the strongest evidence as to the age of the violin was obtained from the reference chronologies of two violas whose origin had already been identified. A graph generated from all the ring-width data, including James’ violin, is shown below in Figure 13.

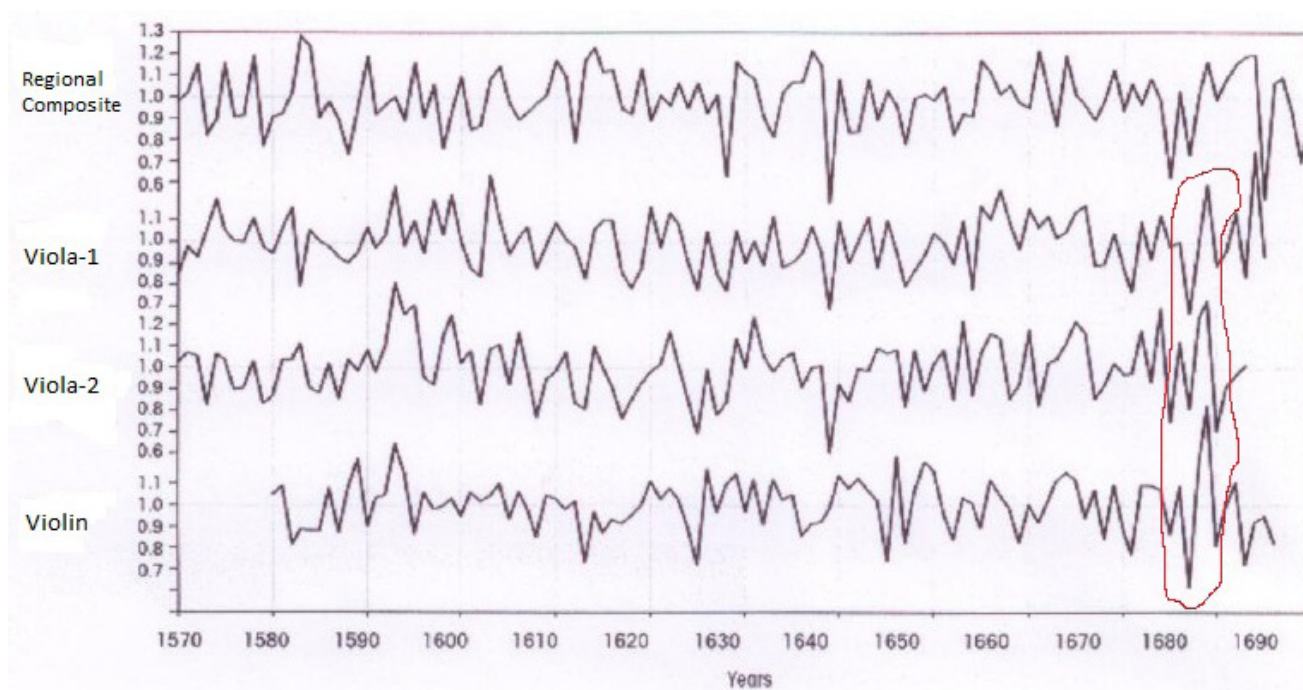


Figure 13. Graph of ring-width data. Credit: Adapted from Grissino-Mayer et al., 2002.

The top graph line labeled “Regional Composite” is the chronology developed for trees in the forests of Northern Italy, where the wood for the violin came from. How well does the sawtooth top line match up with the bottom line on the graph, which is James’ violin? Henri and his colleagues suspect that the reason it does not match may be the result of the wood in James’ violin having come from a tree on the same mountain slope, but at a lower elevation. This would create a very different microenvironment—temperature, rainfall, vegetation types, etc.—than higher on the slope. Nevertheless, when the areas within the red circle on the graph, which are the youngest rings from the two violas and James’ violin, are compared, very distinct and similar patterns emerges. Henri and his colleagues used these data to determine that the spruce wood in the top of James’ violin came from a tree that had been cut down in 1686!

You may now be asking yourself, “So what! James has a violin that was made in the late 17th or early 18th century, big deal.” Well...it just might be a really big deal! Henri himself once said, “Dendrochronologists can only assign dates to...tree rings. We cannot conclusively prove that [a] violin was made by [a particular luthier-violin maker]. Rather we can only prove that [a luthier] could not have made [a] violin should the tree rings post-date his death. Tree ring dates that are contemporary with [a luthier’s] working career...however can provide substantive scientific support to the claim that [a specific luthier] made [a] particular violin.”

As far as James was concerned, for \$3 he purchased a “genuine” antique! The next big question: If this were your violin, would you display it on a fireplace mantle? Read the Postscript, and then answer that question for yourself!

Part VI – Postscript

Violins that have “substantive scientific support” and/or a bonafide label that clearly identifies its maker command prices at auctions that few people can afford. Below is a brief summary of several violins that were sold at auction made by the famed luthier, Antonio Stradavari:

- A Stradivari violin (Strad, for short) known as *The Alard* sold at auction in 1981 to a collector in Singapore for \$1.2 million.
- A Stradivari violin made in 1707 sold for what was then a world record price of \$3,544,000 by Christie’s in 2006. This violin was called *The Hammer* after its first recorded owner—a Swedish collector named Christian Hammer. The previous record price paid at public auction for a Stradivarius violin was \$2,032,000 for the *Lady Tennant* also by Christie’s in NY in April 2005.
- *The Molitor*, a Stradivarius made in 1697, once belonged to a general in Napoleon’s army named Count Gabriel Jean Joseph Molitor. It was sold in 2010 by Tarisio Auctions to violinist Anne Akiko Meyers for \$3,600,000, a world record at the time.
- In 2011, Stradivari’s Lady Blunt violin (1721), which is in pristine condition (see Figure 14 below), was sold by Tarisio Auctions for £9.8 million (\$15.9 million). The violin is named after Lady Anne Blunt, the granddaughter of the English poet Lord Byron. Lady Blunt had owned it for 30 years. This same violin had been sold at auction by Sotheby’s in 1971 for the then-record amount of £84,000 (\$200,000).
- Behold *The Messiah*...violin (1716)! Seldom played, this violin was kept in Stradivari’s shop until he died in 1737, which probably accounts for its mint condition (Figure 14). It takes its name from a remark made by violinist Jean-Delphin Alard, who was the son-in-law of the highly skilled, but somewhat infamous, luthier Jean-Baptiste Vuillaume. Apparently, Vuillaume’s infamy came from his ability to “copy” the productions of other more well-known luthiers. As the story goes, Alard was present when then-owner of the violin, Luigi Tarisio, was discussing the merits of his heretofore unseen instrument with Alard’s father-in-law. Overhearing the conversation, Alard remarked, “Then your violin is like the Messiah: one always expects him, but he never appears.” Upon Tarisio’s death in 1854, Vuillaume purchased it in 1855, but only publicly showed it once...three years prior to his own death in 1875. After Vuillaume died, the violin became the property of his two daughters and then of his son-in-law. When Alard died in 1888, his heirs sold the “Messiah” in 1890 to W.E. Hill and Sons for £2,600 British pounds (US \$4,092.14). At the time, it was the largest sum ever paid for a violin. W.E. Hill and Sons considered that a masterpiece of Stradivari, in such perfect condition, should be preserved in [its] pristine state for posterity. In 1939, they presented it to Oxford’s Ashmolean Museum (UK), where it resides enclosed in a glass case on permanent display. (Figure 1 in Part I of this case is of the Messiah violin.)

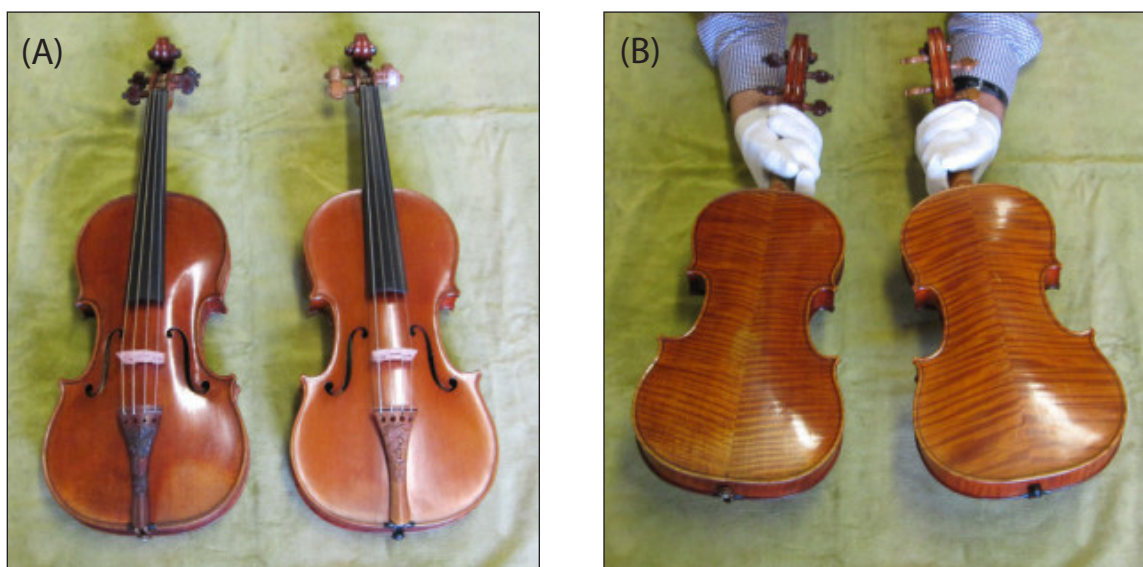


Figure 14. Comparison of Lady Blunt and Messiah violins. In both photos, Lady Blunt is left and Messiah is right. *Credit:* Tarisio.

Questions

1. Why was Henri able to use the data (inside the red circle in Figure 13) to determine that the wood for the top of James' violin came from a tree that had been cut down in 1686? Write two specific and logical reasons, based on what you have learned in this case study.
2. Hypothetically speaking, if the entire core that was skeleton plotted and dated in Part IV was real wood, could the core have come from the *very same tree* from which James' violin was made? Why or why not? Identify two specific reasons for your answer; cite sources, if necessary!
3. Imagine that the simulated core, skeleton plotted and dated in Part IV using the master chronology, was real and the wood came from the very same spruce tree forest in Northern Italy from which James' violin was made. If wood from the tree from which the core sample was taken had been used to make a violin, based on the dates determined from the master chronology, who might have been the luthier(s) responsible for making it? Correctly cite at least one source to support your answer.

References

- Burckle, L., and H.D. Grissino-Mayer. 2003. Stradivari, violins, tree rings, and the Maunder Minimum: a hypothesis. *Dendrochronologia* 21(1):41–45.
- Grissino-Mayer, H.D. 2016. The science of tree rings [website]. <<http://web.utk.edu/~grissino/>>.
- Grissino-Mayer, H.D., P.R. Sheppard, and M.K. Cleaveland, M. K. 2002. Mastering the rings. *The Strad* April 2002, 408–415.
- Grissino-Mayer, H.D., P.R. Sheppard, and M.K. Cleaveland. 2004. A dendroarchaeological re- examination of the “Messiah” violin and other instruments attributed to Antonio Stradivari. *Journal of Archaeological Science* 31(2), 167–174.
- Laboratory of Tree-Ring Research, University of Arizona [website]. *n.d.* <<http://ltrr.arizona.edu/>>.
- National Gardening Association. 2001. The learning garden: from seed to seed [website]. <<https://garden.org/onlinecourse/PartI15.htm>>.
- Speer, J. *n.d.* Dendrochronology web pages [website]. <<http://isu.indstate.edu/jspeer/dendro/>>.
- Stokes, M.A. and T.L. Smiley. 1968. *An Introduction to Tree-Ring Dating*. University of Chicago Press, Chicago 73 pp. *Useful resource for an explanation of tree growth.*
- Tarisio: Fine Instruments & Bows [website]. *n.d.* <<http://tarisio.com/cozio-archive/property/?ID=40111>>. *Contains quotations from a book entitled: The Hill Collection of Musical Instruments, David D. Boyden, Oxford University Press, London, 1969.*
- Topham, J., and D. McCormick. 2000. Focus: a dendrochronological investigation of stringed instruments of the Cremonese School (1666–1757) including “The Messiah” violin attributed to Antonio Stadivari. *Journal of Archaeological Science* 27, 183–192.
- Topham J. and McCormick D. The ring saga. *The Strad* 108: 404-411, 1997.
- Wikipedia.*
- Hammer Stradivarius: <https://en.wikipedia.org/wiki/Hammer_Stradivarius>
 - Lady Blunt Stradivarius: <https://en.wikipedia.org/wiki/Lady_Blunt_Stradivarius>
 - Lady Tennant Stradivarius: <https://en.wikipedia.org/wiki/Lady_Tennant_Stradivarius>
 - Messiah Stradivarius: <https://en.wikipedia.org/wiki/Messiah_Stradivarius>
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