

The Right Date for the Wrong Part of the Shroud of Turin

William David Cline

トリノの聖骸布の不適切な部分の正しい年代

ウイリアム デイビッド クライン

Abstract

A major reason that the Shroud of Turin is dismissed from serious study is the radiocarbon date of 1260 to 1390 A.D. by laboratories in Oxford, Zurich, and Arizona. The dating was done in 1988 and reported in 1989. Because the dates given were so out of keeping with other evidence indicating that the Shroud is much older, researchers have proposed a number of ideas as to how such a recent date could have been given. The proposal with the most evidence is explained in this paper. It appears that little attention was given to selecting suitable samples of the Shroud for radiocarbon dating. Thus, a sample was selected which is not representative of the whole cloth. How this happened and evidence for it are explained.

Key words : shroud of Turin, science and religion, radiocarbon dating sample

(Received September 30, 2008)

抄 録

トリノの聖骸布が真剣に研究されない主な理由は、オックスフォード、チューリヒ、アリゾナの実験室で、放射性炭素による年代測定がされた結果、1260年～1390年のものと認められたからである。この測定は、1988年に行われ、1989年に報告された。ここで得られた年代が聖骸布をより古い年代とする証拠と一致しないので、なぜそのような新しい年代になったのかについて、研究者たちは様々な見解を提出した。本稿では、最も有力な証拠をもつ見解が説明されている。年代測定のために、聖骸布の適切なサンプルが注意深く選ばれていなかったようである。つまり、選ばれたサンプルは、布全体を代表するものでなかった。本稿では、このようなことが起きた経緯、並びにその証拠について述べられている。

キーワード：トリノの聖骸布、科学と宗教、放射性炭素年代測定サンプル

(2008年9月30日受理)

Introduction

A recent article by Chet Raymo (2008) illustrates some common attitudes towards the Shroud of Turin. Most of the article is a reprint of what first appeared in 1989 after C-14 radiocarbon tests had shown dates for the Shroud of 1260 to 1390 AD. The author states that the report on the radiocarbon dating of the Shroud which appeared in *Nature* (February 1989) is “a classic illustration of the scientific way of knowing...” To his reprinted article, the author had added two comments. The first is February 3, 2005 and is a response to a reader who asks why the author has not responded to the report of chemical tests in 2005 indicating that the Shroud is between 1,300 to 3,000 years old. The response is in Addendum 1,

The answer is simple. I prefer to wait until I read the original scientific paper, and analyses of the paper's content by knowledgeable chemists.... In the meantime, an objective observer should assume that the Shroud is a 14th-century religious icon or outright fraud. That is when the Shroud first appears in the historical record, and that is when carbon-dating assigns its origin. It was a time when religious icons were commonly manufactured or assumed. Why evoke miracles when a perfectly natural explanation is more plausible?

In Addendum 2 Raymo further adds,

You will have noted that a commenter here suggested recently that I am not aware of the considerable literature on the Shroud. I am indeed aware of it, but I have better things to do that [sic] read the many books and web sites that support the Shroud cult, just as I don't bother reading the voluminous literature on alien abductions or astrology. In matters such as this, for which I have very little personal interest, I reply [sic] on the filter of the peer-reviewed scientific literature. When one of the two weekly peer-reviewed journals to which I subscribe – *Nature* and *Science* – takes notice, so will I. Be assured that I am open to any possibility.

While Raymo strongly encourages confidence in the 1260 to 1390 date of the Shroud based on the *Science* article he is unwilling to read any other of the literature about the Shroud. There is plenty of scientific information available besides what appears in *Nature* and *Science* and it should be noted that many of the scientists involved in the intensive study of the Shroud have been motivated by the scientific challenge presented by it.

There is evidence indicating that the Shroud of Turin is not a product of the 14th Century but is an ancient cloth related to the death and resurrection of Jesus Christ. However, the Carbon-14 dating done by the Oxford, Zurich, and Arizona laboratories in 1988 has been very troubling for Shroud research. For some, the carbon dating alone has settled the issue and the Shroud is a fraud. However, the more deeply one studies the subject, the more troubling the Carbon-14 date becomes. Surprisingly, the Carbon-14 date is very likely correct. The samples

used for the Carbon-14 dating could well have been products of the 14th Century but the rest of the Shroud was not. An explanation of how that could have happened and evidence for that view will be presented in this paper.

The Radiocarbon Dating

The Shroud of Turin attracted great interest when it was first photographed in 1898. As the photographic negative was developed, an unexpectedly clear positive image emerged of a man resembling many artistic portraits of Jesus Christ. A second set of photographs in 1931 by Enrie confirmed the reality and accuracy of these images. In 1976 some of the photographs of the Shroud were placed under a VP-8 image analyzer and once again great interest was created. Under the VP-8 the image on the Shroud showed three-dimensional characteristics. An extensive 1978 examination of the Shroud by a group consisting largely of American scientists, Shroud of Turin Research Project (STURP), revealed nothing to prove that the Shroud was not authentic although the scientists were careful to state that there was no strictly scientific proof to show that the Shroud was authentic (Heller, 1983, p. 217).

Calls went out for Carbon-14 dating of the Shroud to either prove that it was produced in the time of Jesus or that it was a forgery produced in Medieval times. Radiocarbon dating was developed between 1946 and 1955 by Willard F. Libby, a chemist at the University of Chicago. The test measures the ratio between C-12 which is stable, and C-14 which decays at a fixed rate after a living organism dies (Guerrera, 2001, p. 114). Since the flax used to make the linen cloth of the Shroud was a living thing, a C-14 test should be able to tell when the flax was grown.

Early C-14 testing would have required large amounts of the Shroud to have been consumed, up to 870 square centimeters. That was clearly unacceptable. In 1977, Accelerator Mass Spectrometry (AMS) C-14 dating was developed which required much less material for a date to be determined. Efforts began to arrange for testing on the Shroud to be done. In 1982 the STURP team began studying this issue and in 1984 submitted a 177-page proposal to Cardinal Ballestrero, the Archbishop of Turin. Their proposal called for six samples to be taken from six different areas of the Shroud to be distributed to six laboratories for C-14 testing (pp. 116-117).

In 1983, six radiocarbon laboratories took part in an intercomparison test in preparation for possibly dating the Shroud. This test was arranged by Michael Tite of the British Museum's Research Laboratory. The six laboratories were sent samples of ancient Egyptian linen and Peruvian cotton textile. In 1984 results of the tests were collected and compared. Most laboratories were in agreement on the dates except that one laboratory had a result that differed by about 1,000 years (Gove, pp. 77-79). This error was attributed to mistakes that were

made in Bern, Switzerland while preparing the sampling carbon (Gove, 1996, p. 91).

In 1985, in Trondheim, Norway, at the International Congress of Radiocarbon Dating, Harry Gove of the University of Rochester, a co-inventor of the AMS testing, was “acting as a spokesman for the six laboratories and the British Museum” (p. 106). He proposed that the laboratories involved in testing the Shroud separate from STURP. STURP had proposed that 26 tests be done on the Shroud, with carbon dating being number six. However, Gove contended, “Carbon dating is by far the most important test and certainly the test that should be made first” (p. 84). The six laboratories did agree to separate from STURP and they agreed to a number of scientific protocols to ensure reliability for the tests. These protocols were modified in a meeting at Turin in 1986. However, afterwards, in 1987 the Turin authorities announced several changes in the protocol including that the number of laboratories would be reduced to three, at most. The Turin authorities responded to criticism by stating that fewer laboratories would be able to do the dating with less sampled material and less damage to the Shroud. In response to this, Gove wrote an open letter to the Turin authorities stating that the changes in the protocols “...will produce an age for the Turin Shroud which will be vastly less credible than that which would have been obtained if the original Turin Workshop protocol had been followed” (Guerrera, p. 124). Gove wrote this out of his concern to have more laboratories involved in dating the Shroud and not out of concern for taking fewer than six samples from differing areas of the Shroud.

On April 21, 1988, the Shroud was taken out of its reliquary and placed on a table for the sample to be cut. The procedure was videotaped so it is possible to see the two people in charge of cutting the sample arguing for over an hour about the place to cut (Case, 1996, p. 39). Contrary to recommendations that samples be taken from different areas of the Shroud, a single sample was taken from one corner. That corner was known as the Raes corner because in 1973 Gilbert Raes, of the Ghent Institute of Technology, was allowed to remove a sample for study. Giovanni Riggi, a microanalyst of Turin, cut the sample from the Shroud in a single 81 mm x 16 mm strip (Guerrera, p. 127). He said that the original 8 square centimeters of cloth that he cut “...was then reduced to about seven 7 cm because fibres of other origins had become mixed up with the original fabric” (Riggi, 1988, cited in Marino & Benford, 2000, p. 2). Half of the sample was cut into pieces and those pieces, together with control samples, were given to representatives of the Oxford, Zurich, and Arizona laboratories. These laboratories seem to have been chosen because out of the original six laboratories, these three had the most experience with C-14 dating (Gove, p. 157).

The British Museum, according to protocol, released the official findings of the C-14 dating of the Shroud on October 14, 1988. The dates for the Shroud, written in chalk on a blackboard, can be seen in photographs of the event—1260-1390! Although some leaks of the date had already occurred, newspapers around the world printed stories about the Shroud

using terms such as fake, fraud, forgery, and hoax. The *Nature* article on the Radiocarbon Dating of the Shroud appeared in February 1989. Although standard procedure called for *Nature* articles to be peer reviewed, according to Guerrero, in this case, the standard procedure was not followed (p. 133).

The Controversy

Since there is considerable historical and scientific evidence contrary to the C-14 dating which indicates that the Shroud is much older, several hypotheses have been advanced to explain the discrepancy. Paul Maloney summarized the hypotheses as follows:

1. Fraud by Church officials or by the radiocarbon dating laboratories skewed the dates.
2. Water poured on the Shroud to put out the fire of 1532 skewed the dates.
3. Heat from the fire (or combined with water) skewed the dates.
4. A bio-plastic coating caused by mold and bacteria on the fibers skewed the dates.
5. A neutron flux caused by the resurrection skewed the dates.
6. Reweaving and repair in the radiocarbon dating sample area skewed the dates.
7. Carbon monoxide unique to the Shroud's historic locations skewed the dates (2008).

For each hypothesis some comment is in order. Fraud is highly unlikely and is not characteristic of those involved in the dating of the Shroud. Tests for water and fire damage can be done on linen but scientifically replicating the same conditions of 1532 is impossible. If a bio-plastic coating contaminated the fibers of the radiocarbon test, the sample would have had to consist of 60% contamination (Wilson & Schwartz, 2000, p. 100) or 79% contamination according to Gove (p. 303). Neutron flux and its effect on the dating of ancient linen fragment dating can be tested and can skew the dating to reflect a more modern age (Barbesino & Moroni, 2008). However, whether or not a neutron flux affected the Shroud is unknown and even if a neutron flux had affected the Shroud, the intensity would be unknown. The reweaving and repair hypothesis has considerable evidence in its favor which will be explored below. The carbon monoxide hypothesis is under further investigation at present (Correll, August 17, 2008).

There are a number of indications that the material used for the C-14 tests was different than the material in the rest of the Shroud. If it was different, it could not accurately represent the rest of the Shroud. First, are the observations noted above concerning the contamination of the sample with foreign threads at the time of its cutting by Riggi. Related to this is a note in the conclusion of the *Nature* radiocarbon dating article, "Oxford thank P. H. South (Precision Process (Textiles) Ltd, Derby) for examining and identifying the cotton found on the shroud sample" (Damon, et al., 1989). Furthermore, a chemical analysis of the radiocarbon sample from the Shroud was not performed by any of the three laboratories involved in the dating

(Wilson & Schwartz, p. 102). The single sample and lack of chemical analysis were serious failings in the radiocarbon dating. During the discussions that took place in Turin to establish a protocol for the sampling, the textile expert, Madame Flury-Lemberg of Switzerland was included.

Flury-Lemberg stated that the cloth is the same from one end to the other. There is no need to take samples from various places. One could take strips from the edges of the main cloth from any place and it would be the same. (Gove, p. 155)

Although Flury-Lemberg was head of the Textile Workshop, Abegg-Stiftung, in Bern, her visual assessment of the Shroud was not the same as a chemical assessment. However, her view seemed to prevail. Contrary to her view, the archaeologist, William Meachan argued unsuccessfully for multiple samples to be taken from the Shroud but his arguments were viewed by Gove as “remarkably inappropriate as applied to the shroud” (Gove, p. 155). From the viewpoint of the radiocarbon dating labs, the issue seemed to revolve around having a good number of laboratories to conduct the tests in order to increase reliability. They did not give sufficient attention to having a good number of samples to work from.

Based on the above and other compelling evidence, Marino and Benford proposed that a 16th Century invisible reweaving in the area of the C-14 sample accounted for newer material which skewed the dates of the Shroud (2000). They report that Madame Flury-Lemberg countered their argument by stating that this was “technically impossible.” However, Benford and Marino consulted a present day textile repair service, Without a Trace, and were told by the president of the firm that normal reweaving repair is detectable on the reverse side but that “French reweaving” is undetectable. It is extremely expensive and takes considerable time. Benford and Marino point out that the owners of the Shroud, the House of Savoy, had the requisite resources to make such repairs (Benford and Marino, 2005, pp. 1-2). Benford and Marino also found evidence of invisible repair in a 1998 book by Professor Piero Savarino, who was the custodian of the Shroud’s scientific advisor. He co-authored a book in which it states that invisible mending had routinely been done on the Shroud (pp. 2-3).

In a 1994 interview concerning the Shroud of Turin and the radiocarbon dating, Dr. Alan Adler stated,

But the real problem in the radiodate sampling, is, a sample of the C14 taken from the middle of the cloth will not necessarily give the same C14 date as the area they took the sample from—on the side of the cloth....Because you only took one sample. So you can talk all you want about how reproducible the date is, but you can’t talk about how accurate it is. You have no way of knowing if the area you took the C-14 sample from represents the whole cloth. That’s an area which has obviously been repaired. There’s cloth missing there. It’s been rewoven on the edge. They even cut part of it off, because it was obviously rewoven on the edge. The simplest explanation why the date may be off is

that it's rewoven cloth there. And that's not been tested. (Case, p. 72-73)

However, in 2004 Raymond Rogers did test fibers from the sample area. Before examining his findings it is worthwhile to establish his standing among scientists related to the Shroud. He was Director of Chemical Research for STURP. His reputation was such that even Harry Gove, a fierce critic of STURP, wrote that in 1996, "I was saddened to hear that Rogers had left STURP because he was one of the few scientists in that organization for whom I had real respect" (Gove, p. 128). Rogers was a UCLA/Los Alamos Fellow, a co-founder of the Coalition for Excellence in Science Education, a member of the Air Force Scientific Advisory Board, and he had published over 50 peer-reviewed papers in scientific journals (Marino & Benford, 2008).

In 1978, as a part of the STURP investigation, Rogers took samples of linen fibers from numerous areas of the Shroud and the linen Holland cloth which had been attached to the back of the Shroud after the fire of 1532. In 2003, he received thread samples taken from the center of the radiocarbon dating sample. Prof. Luigi Gonella, scientific advisor to the Cardinal of Turin, had taken these threads from the radiocarbon sample before it was distributed to the dating laboratories (Rogers, 2005, p. 190). These samples enabled Rogers to analyze both the Shroud and the radiocarbon dating samples. What motivated Rogers to do the analysis is that he had read the Marino and Benford 2000 paper with the hypothesis that a reweaving repair on the radiocarbon dating sample area of the Shroud had introduced new materials which gave a too recent date for the Shroud. Rogers said that when he heard about this he considered it the last straw. Here were people untrained in chemistry, making theories based merely on visual observations. He thought that with the materials he had on hand, he could prove them wrong in short order. However, within an hour he came out of his lab saying that Marino and Benford might be right after all (Schwartz, 2008).

First, Rogers reported that tests of the Shroud's fibers showed no traces of vanillin. This was the same as samples from the Dead Sea scrolls and other ancient linens in which all traces of vanillin had disappeared. However, medieval linens, the Raes sample, and the Holland cloth attached to the Shroud still retained vanillin and "gave a clear test" (Rogers, 2005, p. 190). Rogers calculated that had the linen of the Shroud been produced between 1260 and 1390, 37% of the vanillin would still have been present in the fibers. Depending on the temperature for storage, the complete lack of vanillin in the main part of the Shroud indicated that it was from 1,300 to 3,000 years old. Next, Rogers reported "colored encrustations (or coatings)" on the Raes sample and the radiocarbon sample threads. "There was absolutely no coating with these characteristics on either the Holland cloth or the main part of the shroud." Furthermore, he reported finding a yellowish gum dye and cotton fibers in the two samples but not in the main part of the Shroud. The type of gum dye Rogers found was an extract from the Madder root which was first used in Italy from about 1291 A.D. Aluminum was also found

in the material coating the sample fibers. Rogers cites a 2002 report by Adler, Selzer, and DeBlase who found 20 times the concentration of aluminum on radiocarbon sample threads compared to other Shroud threads based on X-ray elemental analyses. Aluminum was used in dyeing cloth in hydrated oxide form (Porter, 2004). What the chemical analysis showed Rogers is that repairs had been made to the Shroud, as Marino and Benford suggested, and that the newer material had been dyed to match the older material (p. 192). Since this evidence was characteristic of the Raes and radiocarbon sample threads, Rogers concluded that the radiocarbon sample was “not part of the original cloth and is invalid for determining the age of the shroud” (p. 193). Roger’s paper was published in *Thermochimica Acta*, a peer-reviewed journal which “publishes original research contributions covering all aspects of thermoanalytical and calorimetric methods and their application to experimental chemistry, physics, biology and engineering” (Elsevier, 2008).

Additional support for Rogers came from John L. Brown of the Georgia Institute of Technology who examined a Raes weft thread with an electron microscope and found a yellow-brown coating except in indented areas where the warp thread intersected. He also found cotton fibers among the sample (Brown, 2005, p. 2). Most recently, Robert Villarreal of Los Alamos Laboratory presented additional evidence confirming the work of Rogers. Villarreal was able to use High Resolution Photo-Microscopy, Fourier Transform Infrared Spectroscopy, and Time-of-Flight Secondary Ion Mass Spectrometry for his analysis. First of all, a thread sample from the Raes Corner, taken from next to the C-14 sample, showed evidence of having been spliced. Photos of the spliced thread show a darker and tighter spun part and a lighter colored loosely spun part on either end of the splice. No spliced threads were found on the main body of the Shroud. On the main body of the Shroud, where weavers came to the end of a thread, a new thread was simply laid next to it and weaving continued. Another finding was a resin coating on the threads. Finally, analysis of the spliced thread and other threads from the Raes Corner identified cotton spun together with linen, indicating that the material in that area was different than the material in the rest of the Shroud (Villarreal, 2008 and *New Findings*, 2008).

Rogers suggests that cotton was most likely added to the Shroud repair because cotton more readily takes dyes and coloring than linen. Cotton enabled a more precise coloring of the patched fabric to match the older, original material (2008, p. 70). The main part of the Shroud is composed of linen that was produced and woven with technology consistent with that used in the Middle East during the time of Christ. There were a number of changes in linen production and in weaving which are evident in later, European linen cloths. Consistent with Jewish production in or near the time of Christ, it was very important to follow laws such as that of Leviticus 19:19, “...nor shall you put on a garment made of two different materials” and similarly, Deuteronomy 22:11, “You shall not wear clothes made of wool and linen

woven together” (NRSV). The main part of the Shroud, composed only of linen, was woven in accord with these clear scriptural teachings. However, the area in and near the C-14 sample shows weaving that ignores these rulings. If a patch had been made in the 1500’s, as Benford and Marino propose, the repairers in Europe would not have been bound by Jewish customs and laws. Their only motivation would have been to make a repair as esthetically pleasing as possible. The use of cotton in the repaired area is consistent with this.

If there was a patch skillfully woven into the Shroud’s fabric in the 1500’s, how is it that the radiocarbon date is from 1260 to 1390? Marino and Benford proposed that 60% of the patch could be composed of material from the 1500’s and 40% of the material could be original threads. That ratio produces the radiocarbon date that was announced in 1989 (2000). More recently, they have proposed a 67/33 ratio of original and newer materials in the patch (Benford & Marino, 2008). Another possibility is that some patch material may have come from relatively older medieval cloth or yarn that was dyed to match the color of the Shroud. Further rigorous scientific testing may be able to more precisely determine the nature, age, and sources of the materials.

Conclusion

Despite the observations and scientific findings, particularly of Rogers, that the C-14 sample was not valid for dating the Shroud, there have not been any headlines announcing this to rival the headlines proclaiming that the Shroud was a fake. The material tested in 1988 that was taken from the Shroud of Turin was not part of the original cloth. Some percentage of the test sample may have been original material but there was enough new material to invalidate the sample for dating the Shroud. Harry Gove details the efforts to include six laboratories to date the sample but he also reveals that relatively little attention was placed on obtaining a suitable sample and the efforts to obtain multiple samples from the Shroud were rejected. Thus, the date for the Shroud of 1260 to 1390 cannot be valid. This scientific evidence should be more widely acknowledged.

Returning to the negative response to the Shroud of Turin cited at the beginning of this paper, it is now possible to read the research published by Rogers showing that the C-14 sample did not represent the Shroud of Turin and that the Shroud is much older. Furthermore, it is possible to read support for Rogers’ contention by other knowledgeable chemists. A response can also be given to the argument that the Shroud is obviously a fraud because lots of fraudulent religious icons were being produced at the time the Shroud first appeared in Europe. While it is true that there are many manufactured religious icons, the Shroud of Turin presents an enigma. First of all, why would a forger go to such extensive trouble to produce the Shroud when it was easy to make a fake relic and sell it as genuine? There are details,

invisible to the naked eye, in the blood flows and chemistry of the blood on the Shroud that medical doctors and chemists have documented to be medically accurate. The microscopic pollen found on the Shroud indicate an origin in Jerusalem (Danin, Whanger, Baruch & Whanger, 1999). In addition, how would a medieval forger know to put microscopic amounts of calcium, unique to Jerusalem, in the areas of the feet and the knees? Also, the art of medieval Europe shows details of the crucifixion known to be historically inaccurate that differ from details on the Shroud which are historically accurate. Why would a forger step out of his contemporary time frame to do this? Additionally, the method of production of other relics can easily be determined but the image on the Shroud has not been fully explained or replicated to this day.

It may be scientific to assume that the Shroud is a fake based on the premise that there is a naturalistic explanation for everything but that premise is challenged by the Shroud of Turin. Scientific study of the Shroud has not proven it to be a fake. On the contrary, reviewing 25 years of scientific study, Raymond Rogers wrote, as follows, of the Shroud,

I believe that the technology of the cloth indicates a much greater age than shown by the 1988 date. I believe that we can prove categorically, without any assumptions, that the sample taken in 1988 was invalid. I believe that the image could not be a hoax. Based on its chemical composition, I believe that the Shroud is a real shroud. I believe that those opinions are all that can be justified on the basis of the facts and observations we now have. However, no observations to date rule out the possibility that the Shroud may very well be the actual shroud used with Jesus. My conclusion is that the Shroud may be the most important object in history. It deserves only the most careful, meticulous study and careful preservation. (2003)

Acknowledgements

The author is grateful to M. Sue Benford, Joseph Marino, and Paul Maloney for comments and corrections given for drafts of this paper.

References

- Barbesino, F & Moroni, M. (2008, August). Neutron Radiation Effects on Linen Fibers and Consequences for a Radiocarbon Dating. Paper read at the conference, The Shroud of Turin: Perspectives on a Multifaceted Enigma, Columbus, Ohio.
- Benford, M. & Marino, J. (2005). New Historical Evidence Explaining the "Invisible Patch" in the 1988 C-14 Sample Area of the Turin Shroud. Retrieved May 6, 2006 from, <http://www.shroud.com/papers.htm>
- Benford, M. & Marino, J. (2008, July-August). Discrepancies in the Radiocarbon Dating Area of

- the Turin Shroud. *Chemistry Today*, 26:4, 4-12.
- Brown, J. (2005). Microscopical Investigation of Selected Raes Threads from the Shroud of Turin. Retrieved August 5, 2008 from, <http://www.shroud.com/papers.htm>
- Case, T. (1996). *The Shroud of Turin and the C-14 Dating Fiasco*. Cincinnati: White Horse Press.
- Correll, D. (August 17, 2008). Shroud of Turin Stirs New Controversy. Los Angeles Times. Retrieved September 4, 2008 from, <http://www.latimes.com/features/religion/la-na-turin17-2008aug17,0,4950965.story>
- Damon, P., Donahue, J., Gore, B., Hatheway, A., Jull, A., Linick, T., et al. (1989, February 16). Radiocarbon Dating of the Shroud of Turin. *Nature*. 6208, 611-615, Reprinted by permission and retrieved September 1, 2008 from, <http://www.shroud.com/nature.htm>
- Danin, A., Whanger, A., Baruch, U. & Whanger, M. (1999). *Flora of the Shroud of Turin*. St. Louis: Missouri Botanical Garden Press.
- Elsevier. (2008). *Thermochemica Acta* Product Description. Retrieved August 5, 2008 from, http://www.elsevier.com/wps/find/journaldescription.cws_home/500855/description#description
- Gove, H. (1996). *Relic, Icon or Hoax? Carbon Dating the Turin Shroud*. Bristol: Institute of Physics Publishing.
- Guerrera, V. (2001). *The Shroud of Turin: A Case for Authenticity*. Rockford, IL: Tan Books.
- Heller, J. (1983). *Report on the Shroud of Turin*. Boston: Houghton Mifflin.
- Maloney, P. (2008, August). What went wrong with the Shroud's radiocarbon date? Setting it all in context. Paper presented at the conference, The Shroud of Turin: Perspectives on a Multifaceted Enigma, Columbus, Ohio.
- Marino, J. & Benford, M. (2000). Evidence for the Skewing of the C-14 Dating of the Shroud of Turin Due to Repairs. Retrieved September 26, 2008 from, <http://www.shroud.com/pdfs/marben.pdf>
- Marino, J. & Benford, M. (2008, August). Invisible Mending and the Turin Shroud: Historical and Scientific Evidence. Paper read at the conference, The Shroud of Turin: Perspectives on a Multifaceted Enigma, Columbus, Ohio.
- New Findings Reveal that the Sample Used to Carbon-date the Shroud of Turin was not the Original Linen. (August 15, 2008). Society & Religion. Retrieved September 9, 2008 from, <http://societyandreligion.com/new-findings-reveal-that-the-sample-used-to-carbon-date-the-shroud-of-turin-was-not-the-original-linen/418/>
- Porter, D. (2004). Shroud of Turin Facts Check: Carbon 14 Dating and the Shroud of Turin. Retrieved September 19, 2008 from, <http://www.factsplusfacts.com/shroud-of-turin-carbon-14.htm>
- Raymo, C. (August 17, 2008). "He preferentially believes." Science Musings. Retrieved August 31, 2008 from, <http://www.sciencemusings.com/2008/08/he-preferentially-believes.html>
- Rogers, R. (2003). Personal correspondence with Professor Giulio Fanti reprinted in the conference program, The Shroud of Turin: Perspectives on a Multifaceted Enigma, Columbus, Ohio.
- Rogers, R. (2005). Studies on the radiocarbon sample from the shroud of turin. *Thermochemica*

Acta. 425(1-2) 189-194. Retrieved September 20, 2007 from <http://www.shroud.it/ROGERS-3.PDF>

Rogers, R. (2008). *A Chemist's Perspective on the Shroud of Turin*. [Privately published] Florissant, CO: Barrie M. Schwartz.

Schwartz, B. (2008, August). Ray Rogers in His Own Words. Video presented at the conference, The Shroud of Turin: Perspectives on a Multifaceted Enigma, Columbus, Ohio.

Villarreal, R. with Schwartz, B. & Benford, S. (2008, August). Analytical Results on Threads Taken from the Raes Sampling Area (Corner) of the Shroud. Paper presented at the conference, The Shroud of Turin: Perspectives on a Multifaceted Enigma, Columbus, Ohio.

Wilson, I., & Schwartz, B. (2000). *The Turin Shroud: The Illustrated Evidence*. London: Michael O'Mara Books.