

Summary of Scientific Research on the Shroud of Turin

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Abstract

According to ancient tradition, the Shroud of Turin is the authentic burial cloth of Jesus. To determine whether this could be true, more historical and scientific research has been done on the Shroud of Turin than on any other ancient artifact. The purpose of this paper is to summarize the results of the scientific research on the Shroud of Turin. This summary is based on the opinions of most Shroud researchers and on research by the author. Research on the Shroud is summarized using nine summary statements. A multi-step argument is given that the image on the Shroud is that of Jesus of Nazareth. Two objections to these conclusions are considered – that they violate the laws of science and that the authenticity of the Shroud is disproven by the 1988 C¹⁴ dating of the Shroud, which concluded that the Shroud dates to 1260 to 1390 AD with a 95% probability. Four reasons are discussed which indicate that this conclusion is not justified by the evidence. This includes consideration of 14 indicators of the Shroud's date and 6 indications that the 1988 statistical analysis of the C¹⁴ dating results was inadequate. The neutron absorption hypothesis is used to explain the apparent C¹⁴ date to 1260 to 1390 AD.

1. Introduction

The “Grand Challenge” of humanity is the correct determination of the nature of reality. It is claimed that the laws of physics and science have been definitively established by use of repeated experiments varying all variables under carefully controlled conditions. Yet it is not possible to prove that all variables that could affect the results of experiments in physics or science have been considered. Specifically, experiments in classical physics could only consider variables within our perception of four-dimensions (three dimensions in space and one dimension in time), whereas results of experiments in modern physics require anywhere from 10 to 26 dimensions to understand, according to string theorists. This indicates that our four-dimensional concept of reality may be only a subset of a much larger dimensionality. If this is the case, then our understanding of the laws of science could only account for variables in our four-dimensional view of reality whereas the laws may also be dependent on variables in the larger dimensionality as well. If this is true, then events could happen that are outside or beyond our current understanding of the laws of physics because they are caused by a change in a variable in the larger dimensionality. This may also be indicated by evidence that certain things or events are outside or beyond our current understanding of the laws of physics. One example of this is the scientific examination of the Shroud of Turin.

A shroud is a piece of cloth in which a person is buried. Turin is a city in north-western Italy. Thus, the Shroud of Turin refers to an ancient burial cloth that has been in Turin, Italy, since 1578. Study of documents, traditions, coins, works of art, pollen, and DNA indicate that it was in Jerusalem, and may have been taken from Jerusalem to Antioch in Syria along with other Christian relics prior to the destruction of Jerusalem in 70 AD. It may have been shown in Galatia in the first century (Gal. 3:1) and taken to Edessa in what is now Turkey probably in the second century. It was later taken to Constantinople where it was located for centuries. It was publicly exhibited in Lirey, France, as Jesus' burial cloth in about 1355-1356. It was then gradually transported across France till it came into Turin in 1578. Thus, there is substantial historical evidence (Ref. 3 to 6, and 38 to 43, as summarized in Section 1 of Ref. 16) which

provisionally establishes that the Shroud of Turin is the cloth that covered the body of Jesus after his crucifixion and death in Jerusalem.

Modern historical and scientific research on the Shroud of Turin started in 1898, when the first photograph of it was taken. Scientific research up to the mid-1980s increasingly supported the authenticity of the Shroud. Public perception of its authenticity probably peaked in the 1980s (Ref. 1) and is now on the rise again (Ref. 2-6) with the growing recognition that the interpretation of the results from the 1988 C¹⁴ dating of the Shroud was significantly flawed (Ref. 3, 5, 6, 18, 19, and 20).

This paper presents a summary of scientific research on the Shroud of Turin. It is based on the majority opinion of Shroud researchers, recent research by the author (Ref. 8 to 20), and consideration of evidence and views presented at the International Conference on the Shroud of Turin (ICST-2017) that was held in Pasco, Washington, July 19 to 22, 2017 (<http://shroudresearch.net/conference-2017.html>).

2. Summary of Scientific Research

Most leading Shroud researchers agree with the following:

1. The Shroud contains good resolution front and back images of a naked man that was crucified exactly as the New Testament says that Jesus was crucified (Figure 1).
2. It was proven in 1978 by the Shroud of Turin Research Project (STURP) that the images are not due to pigment such as paint, stain, or dye, since careful scientific examination of the images indicate they contain no pigment, no carrier, no brush strokes, no clumping of fibers or threads, no capillarity (soaking up of a liquid), and no cracking of the images along the fold lines. It was also proven by STURP that the images are not due to a liquid, a scorch, a photographic process, or any other process that STURP could think of. (Ref. 3 to 6)
3. The above evidence indicates that the images cannot be man-made, either by an artist or by a forger, so the images must have been made in some way by the body that was wrapped within the Shroud. This is the only explanation that is consistent with the characteristics of the image (Ref. 3 to 6, 8 and 9).
4. The Shroud of Turin is the authentic burial cloth of Jesus. For example, all the presenters at ICST-2017 believe that the Shroud is the authentic burial cloth of Jesus, though this was not a requirement to be a presenter.
5. The interpretation of the results from the C¹⁴ dating of the Shroud (1260 to 1390 AD, 95% confidence, Ref. 7) is significantly flawed. See the discussion in Section 6.

The key to doing scientific research on the Shroud is to follow the scientific evidence where it leads, avoiding the constraints imposed by a presupposition of naturalism. Based on this principle, the author has also come to the following conclusions:

1. The discoloration of the fibers that form the image was caused by radiation, so the image is a radiation burn. This is because the image is on the inside of the wrapped configuration and the discoloration mechanism that formed the image required information to control it. The required information is that which defines the appearance of a naked crucified man. This information must have come from the body because it was only inherent to the body, and not to the limestone or air in the tomb. Only radiation could communicate this required information from the body to the cloth (Ref. 9). Information can be communicated by radiation through its energy, intensity, and direction. For example, as we look at the scene in front of us, reflected photons of light entering our eyes carry the information regarding the color, shade, and position of items that allows us to experience what we see. Color is communicated by the photon's energy. Shade (dark vs light) is communicated by the photons' intensity, i.e. number of photons. And position is communicated by the photon's direction as it enters the lens of the eye. The paper "The Role of Radiation in Image Formation on the Shroud of Turin" (Ref. 8) lists 17 evidences that radiation formed the front and back images on the Shroud. Twelve presentations at ICST-2017 were related to image formation. All these presentations were based on the belief that radiation caused the image. This radiation must have been emitted in an extremely short duration burst to discolor only the top two fiber layers in a thread. It is important to realize that such a high intensity burst of radiation is never released in any normal event by a human body, whether living or dead. Thus, the formation of the images on the Shroud appears to require an event that was beyond or outside our current understanding of the laws of physics.
2. The information which defines the appearance of a naked crucified man must have been deposited on the Shroud to control the discoloration mechanism which formed the image. To understand why we can see the image on the Shroud, we need to understand how this information is stored and transferred. We can see the image on the Shroud because the information which defines the appearance of a naked crucified man is now encoded in the pattern of discolored fibers that form the image on the Shroud. This information is transferred to our eyes by reflected light. Our eyes translate this information into electrical signals which travel up our optic nerves, so that when this information reaches our brains we have the conscious perception of an image of a naked crucified man.
3. The radiation that formed the front and back images of the crucified man must have been emitted from within the body to encode some of the bones onto the Shroud (Ref. 8 and 9). Current thought is that the straw-yellow discoloration of the linen that forms the image is probably caused by ultra-violet light and/or charged particles such as protons, based on experiments (Rev. 23 to 29). The high-resolution front and back images on the Shroud, without images of the sides of the body or the top of the head, are most easily explained by the radiation being emitted within the body in vertically collimated directions, both vertically up and down (Ref. 8 and 17).

4. Statistical analysis (Ref. 18 and 19) of the 1988 C^{14} measurement data indicates the presence of a systematic bias that depended on the initial location of the sample on the Shroud. This systematic bias was in addition to the random variations that normally affect all measurements. This systematic bias caused a slope in the measurement data of about 36 years per cm, with the distance measured from the bottom of the Shroud when the Shroud is oriented vertically. This slope in the measurement data is recognized when the average values from the three measurement laboratories are plotted as a function of the distance of the samples from the bottom of the Shroud (Figure 3 of Ref. 19). This means that if the sample location is moved one inch (2.54 cm) further from the bottom of the Shroud, the C^{14} date would change by about 91 years in the forward direction. And to the extent that it can be extrapolated, if the sample location is moved by 13.5 inches (34.2 cm) further from the bottom of the Shroud, then the C^{14} date would change by about 1230 years, which is the difference between the time of Jesus (~30 AD) and the C^{14} date of 1260 AD. A proper understanding of why the Shroud was C^{14} dated to 1260 to 1390 AD ought to account for this slope in the data. The best explanation for this is the neutron absorption hypothesis, which is discussed next.

3. The Neutron Absorption Hypothesis

It is believed that the images were encoded onto the Shroud by a burst of radiation that was emitted from within the body, as the body was wrapped within the Shroud (Ref. 8 and 9). The neutron absorption hypothesis proposes that neutrons were included in this burst of radiation. If neutrons were included in this radiation, a small fraction of these neutrons would have been absorbed in the trace amount of N^{14} in the Shroud to form new C^{14} atoms by the ($N^{14} + \text{neutron} \rightarrow C^{14} + \text{proton}$) reaction. Two other reactions would also produce new C^{14} , but these are of minor significance. This new C^{14} would shift the C^{14} date in the forward direction. To shift the C^{14} date from 30 AD to 1260 AD requires only a 16% increase in the C^{14} atom density at the sample location on the Shroud. Based on experimental evidence, it is believed that the image was most likely formed by a burst of ultra-violet light and/or charged particles such as protons (Ref. 8, 9, and 23 to 29) emitted from within the body. If neutrons were included in this burst of radiation, they would not have been involved in forming the image because they are so penetrating. If they formed the image on the inside of the wrapped cloth, there would also be as strong an image on the outside of the cloth, which is not the case. But the neutrons could have shifted the C^{14} date from the time of Jesus (about 30 AD) to 1260 AD.

Extensive MCNP (Monte Carlo N-Particle) nuclear analysis computer calculations were run based on this hypothesis. The weight of the body that caused the image has been estimated to be about 170 to 175 pounds. The atoms in a body of this weight would contain about 2×10^{28} neutrons. MCNP calculations have determined that emission of about 2×10^{18} neutrons from the body would be needed to shift the C^{14} date at the sample location from 30 AD to 1260 AD. Thus, emission from the body of only one neutron in every ten billion (1×10^{10}) that are in the body would be sufficient to cause this shift in the C^{14} date. If the neutrons were emitted homogeneously (uniformly) from within the body, then the natural distribution that the neutrons would have taken in the tomb, i.e. a cosine distribution, would explain the systematic bias that

caused the slope in the measurement data of about 36 years per cm at the sample location. The carbon dating problem for the Shroud of Turin is dealt with in much greater detail in Ref. 18 to 20.

The first requirement for a scientific hypothesis to be accepted as the explanation of a phenomena is that it must be consistent with what is currently known about the phenomena. This is the attraction of the neutron absorption hypothesis. It is the only hypothesis that is consistent with all the scientific evidence related to C¹⁴ dating and the Shroud of Turin. Only this hypothesis explains:

- Why the samples from the lower left-hand corner of the Shroud, as the Shroud is held vertically, would C¹⁴ date to an apparent value of 1260 AD (uncorrected) rather than to about 30 AD. Neutron absorption in N¹⁴ in the Shroud could produce this date shift.
- Why there would be a slope of about 36 years per cm in the C¹⁴ dates at the sample location. The natural distribution that neutrons would take in a limestone tomb if emitted from the body would produce this slope in the data, depending on how the cloth was folded.
- Why the actual range of the subsample values (1155 to 1410 AD) would occur. This is due to the natural distribution of neutrons over the sample area.
- Why the Sudarium of Oviedo, which according to tradition is the face or head cloth of Jesus (John 20:7), would C¹⁴ date to 700 AD. The date for the Sudarium was evidently shifted less ($700 - 30 = 670$ years) than the date for the Shroud ($1260 - 30 = 1230$ years) because it was placed away from the body in the tomb (John 20:7, Figures 1, 12 and 13 of Ref. 20).

The main alternate concept to the neutron absorption hypothesis is the invisible reweave hypothesis. This concept hypothesizes that the area on the Shroud from which the samples were taken was rewoven with newer material next to the original older material (Ref. 37), so that each sample would contain both old and new material. This hypothesis can explain the date (1260 to 1390 AD) and the slope (about 36 years per cm) but is inconsistent with the range (1155 to 1410 AD) because about ¼ of the 16 measurements should have measured the date for the old material (~ 30 AD), and it cannot explain the 700 AD date for the Sudarium of Oviedo. It is also inconsistent with the continuous horizontal striations in the sample area that are evident in back lighting of the Shroud. See Section 2 of Ref. 20 for more extensive considerations.

4. Is it the Image of Jesus?

According to ancient tradition, the Shroud of Turin is the burial cloth of Jesus of Nazareth. The image on the Shroud shows a naked man who was crucified exactly as the Bible says that Jesus was crucified, yet the characteristics of the image indicate that it is not the result from any normal process. The ultimate questions then are whether the Shroud of Turin is the authentic burial cloth of Jesus, and whether the formation of the image could be consistent with the reported disappearance of his body (Ref. 10 and 11) from within the Shroud in the tomb (John 20:3-9). The evidence indicates that the most reasonable conclusion is that the Shroud of Turin

is Jesus' burial cloth, and that formation of the image is best understood as being caused by an event that is outside or beyond our current understanding of the laws of physics. The logical steps for this conclusion are as follows:

1. Based on scientific investigation of the image characteristics, the image of the crucified man on the Shroud could not be the result of any artist or forger, so it must have been caused in some way by what was wrapped within the Shroud (Ref. 3 to 6, 8 and 9). What was wrapped within the Shroud was a human body that had been crucified, because that is what the image depicts (Figure 1).
2. The image on the Shroud was caused by radiation emitted from the body, because only radiation can communicate the information from the body to the cloth that is required to control the discoloration mechanism that formed the image. The information must come from the body because the information content that defines the appearance of a naked crucified man was only inherent to the body that was wrapped within the Shroud. Without information to control the discoloration mechanism, no recognizable image could be formed (Ref. 8 and 9).
3. The radiation was emitted in an extremely short burst, because only the top one or two layers of fibers in any thread are discolored. A longer duration of radiation will discolor the fibers to a greater depth, as indicated by laser experiments by Paolo De Lazzaro in Italy (Ref. 23 to 27).
4. This burst of radiation was emitted from within the body. This is because the image on the Shroud includes bones (teeth, bones in the hand, etc.) internal to the body, and the information related to the presence of these bones in the body could only have been communicated to the cloth by radiation coming from within the body (Ref. 8 and 9).
5. There is no normal event in which a human body, whether alive or dead, emits such a burst of radiation from within the body that is powerful enough to produce an image of itself on cloth. Such an event is evidently outside of our current understanding of the laws of physics.
6. In all our historical records, only one person and one event are presented as meeting the above characteristics: only Jesus and the disappearance of his body from within his burial shroud in the tomb. The historical events related to the end of Jesus' life on earth as recorded in the Bible (Ref. 10) agree with the above scientific evidence obtained from the Shroud of Turin.

5. Violation of the Laws of Science

The two main objections to the above conclusions are based on an alleged violation of the laws of science and based on the C¹⁴ dating of the Shroud to 1260 to 1390 AD. These objections are discussed next. Other objections are dealt with in Ref. 8.

The first objection related to the laws of science can be stated as follows. For Jesus' body to disappear from within the Shroud as it lay in his burial tomb is scientifically impossible. It violates the laws of science. Disintegration of the atoms in his body would release enough energy to destroy the Shroud, the tomb, the city of Jerusalem, and most of Israel. Obviously, this never happened.

The underlying assumption of this objection is that we know the laws of science with such certainty that we can exclude as impossible anything that is contrary to them. But the “laws of science” should not be viewed in this way. We should not think of them as things that were built into the entire universe at the beginning of time that we have now discovered, so that they are unchangeable. Rather, we should think of them as mathematical descriptions of our collective experience with reality, including all the carefully controlled experiments that have been done in the laboratories around the world. This second view recognizes that what we now call the laws of science are the result of the long historical development of science, so that they may change in the future as new scientific discoveries are made. As mentioned in the first paragraph of the introduction, our current understanding of the laws of science is almost entirely based on a four-dimensional view of reality (three dimensions of space and one dimension of time). But to understand the results of experiments in modern physics, string theorists hypothesize that reality must consist of between 10 and 26 dimensions. This means that our four dimensions that we perceive may be a subset of a much larger dimensionality. Thus, an event can happen in our four-dimensional perception of reality that is beyond or outside of our current understanding of the laws of physics because of a change in a variable in the higher dimensionality. The second part of the objection related to the energy release in the disappearance of the body is dealt with in Ref. 11. It is concluded in this reference that the body did not disappear by a disintegration of the atoms. Rather, it is most reasonable to believe that the body disappeared from within the Shroud by a transition of the body into an alternate dimensionality, which could be possible if reality consists of more than our four dimensions. This means that the atoms in his body did not disintegrate releasing a huge amount of energy, and that his body did not cease to exist after it disappeared from within the Shroud. Rather his body continued to exist in the alternate dimensionality. What is meant by a transition into an alternate dimensionality is illustrated in the short fictional story of Mr. Dotman in Lineland (Ref. 12).

6. C¹⁴ Dating of the Shroud to 1260 to 1390 AD

The second main objection is related to the carbon dating of the Shroud. This objection can be stated as follows. The C¹⁴ dating of the Shroud of Turin in 1988 concluded that the Shroud was made between 1260 AD and 1390 AD, with a 95% probability. Historically, Jesus died about 30 to 33 AD. This proves that the Shroud of Turin cannot be the authentic burial cloth of Jesus.

The following response to this objection requires a basic understanding of isotopes, radiation, and the C¹⁴ dating methodology. A simple description of these items is given in Sections 2 and 3 of Ref. 18. The Shroud of Turin is made of linen. Linen is made of long fibers from the stem of the flax plant. Carbon is a major component of these fibers. The element carbon consists of the isotopes C¹², C¹³, and C¹⁴, all atoms of which contain six protons and six electrons, but contain 6, 7, or 8 neutrons respectively. The ratio of neutrons to protons is too high in C¹⁴ atoms so they decay with a half-life of about 5730 years, which means that half of any specific number of C¹⁴ atoms will decay in this amount of time. The C¹² and C¹³ atoms are stable, i.e. do not decay. While the plant is growing, the C¹⁴ already in the plant is decaying but this loss is exactly compensated by new C¹⁴ brought into the plant during photosynthesis. But after the plant is cut down to make the linen, new C¹⁴ is no longer brought into the plant so that the C¹⁴ concentration decreases due to decay of the C¹⁴ atoms already in the fibers. This allows the date that the flax

plant was cut down to be determined by measurement of the amount of the C^{14} isotope remaining in the linen in comparison to the C^{12} and C^{13} isotopes, with the assumption that the various carbon isotopes have not been added to or removed from the sample since it was cut down.

In 1988, samples were cut from the lower-left corner of the Shroud when it is oriented vertically. These samples were sent to three laboratories for C^{14} dating – the laboratories in Tucson in Arizona, Zurich in Switzerland, and Oxford in England. When the average values from these three laboratories were averaged together, a value of 1260 ± 31 AD (one sigma) was obtained. This is the uncorrected date. When this value was corrected for the changing C^{14} concentration in the lower atmosphere, a range of 1260 to 1390 AD (2 sigma) was obtained. The midpoint of this range is 1325 AD, which is sometimes quoted for the date of the Shroud. These are the values in the statistical analysis of the measured values as reported by Damon, et al., in the British journal Nature in 1989 (Ref. 7). Based on these values, it was concluded that the Shroud of Turin could not be the authentic burial cloth of Jesus but instead was a forgery from 1260 to 1390 AD. The typical layman would have taken this conclusion as authoritative since it was based on the scientific methodology of C^{14} dating, appeared in the very reputable peer-reviewed British journal Nature, and had 21 leading scientists as authors. But scientists involved with C^{14} dating are very aware that contamination of a sample can cause the C^{14} dating methodology to produce very wrong results. And after 30 years of additional study on this issue by the Shroud research community, most researchers believe that the interpretation of results of the C^{14} dating of the Shroud in 1988 is very flawed. The four categories of evidence, discussed below, are as follows:

- The impossibility of forming the image on the Shroud between 1260 and 1390 AD.
- The procedures used by the C^{14} dating laboratories violated the internationally established protocols for C^{14} dating of the Shroud.
- Many evidences indicate that the Shroud is much older than the C^{14} date.
- Detailed statistical analysis of the C^{14} dating measurements indicate that the data is not consistent due to the very likely presence of a systematic bias that affected all the measurements. Unless the bias can be quantified to correct the measured values, the measurement data should not be accepted as necessarily valid.

6A. Impossibility of Creating the Image in the Middle Ages

A five-day hands-on investigation of the Shroud by the Shroud of Turin Research Project (STURP) in 1978 proved that the front and back images of the crucified man on the Shroud contain no pigment, no carrier, no brush strokes, no clumping of anything between the threads or the fibers, and no cracking of the image along the fold lines. Based on this, the images cannot be caused by paint, stain, or dye. STURP also proved that the threads and fibers display no capillarity (soaking up of a liquid) so that the images could not be due to a liquid such as an acid. The Shroud was in a fire in 1532 which would have created a temperature gradient across the image. If the image was due to an organic or inorganic chemical solution, then the temperature gradient would have affected the discoloration. But no affect can be seen, so the image is not

due to an organic or inorganic chemical solution. And STURP proved that the images could not be due to a scorch from a hot object or a photographic process. Subsequent analysis by STURP proved that the straw-yellow discoloration that forms the image is only on the top one or two fiber layers in a thread, with the “top layers” of the thread defined as those facing the body. The discoloration on a fiber is 360 degrees around the outside circumference of the fiber with a discolored thickness of only about 0.2 microns into the 15 to 20-micron diameter of a fiber. The inside of the fiber is not discolored. The discoloration on the outside 0.2 microns of the fiber is caused by a rearrangement of the electron bonding of the carbon atoms that were already in the cellulose molecules that make up the linen fibers. Thus, the discoloration is due to energy added to the cloth to change the way in which the four electrons in the outer orbit of the carbon atoms are shared with the surrounding atoms, but without material/atoms being added to the cloth. And the energy that was added to the cloth must have been added in a very short duration burst of radiation, or multiple very short duration bursts, so that the electron bonding could be altered before the energy was dissipated beyond the top one or two layers of fibers to be discolored in a thread. A longer duration of radiation will discolor the fibers to a greater depth, as indicated by laser experiments by Paolo De Lazzaro in Italy (Ref. 23 to 27).

It is important to realize that this change in the electron bonding of the carbon atoms must be done in a pattern that creates the image of a naked crucified man. How could this be done? The transfer of energy, which is required to change the electron bonding, without the transfer of atoms is a good description of radiation. Because of this and many other reasons (Ref. 8 and 9), it is concluded that the image is a radiation burn resulting from a burst of radiation that must have been emitted from within the body that was wrapped within the Shroud. Because of these image characteristics, there is no known process by which the image could have been made by an artist or forger in the Middle Ages. The technology to make these images did not exist in the Middle Ages and does not exist even today. Also, an artist or forger in the Middle Ages would not have known to, or been able to:

- Place serum rings (visible only under ultraviolet light) around the blood exudate of the scourge marks on the Shroud.
- Add pollen onto the Shroud that is unique to the Jerusalem area, or add pollen around the head that is from a plant with long thorns.
- Put a microscopic amount of dirt in abrasions on the tip of the nose and on one knee.
- Put bilirubin into the blood. Bilirubin is an organic chemical that is produced by the liver when it processes damaged red blood cells when a person has nearly or has been beaten to death. The flogging that Jesus is reported to have received would have been sufficient to produce a very high concentration of bilirubin in the blood.
- Put nanoparticles of creatinine bound to ferritin onto fibers of the Shroud. These nanoparticles indicate that the person wrapped in the Shroud had been heavily tortured (Ref. 31).
- Place nails in the wrists rather than the palms and fold the thumbs under, contrary to all paintings from the Middle Ages.
- Put microscopic chips of travertine aragonite limestone onto the Shroud containing impurities that closely match the limestone in Jerusalem (Ref. 38 and pages 104 to 107 of Ref. 3)

- Use a unique stitch that is most similar to one discovered at Masada, which was destroyed in 73 to 74 AD, to sew the three-inch wide side strip to the main Shroud.
- Create a negative image that contains 3D or topographical information content related to the body-to-cloth distance.

6B. Violation of Established Protocols

Multiple international conferences were held prior to 1988 to determine the required procedures to produce a trustworthy value for the C¹⁴ dating of the Shroud of Turin. Essentially all these protocols were violated (Chapter 8 of Ref. 5 and Chapter 14 of Ref. 6) in cutting the samples from the Shroud, measuring the C¹⁴ quantity in the samples, and doing and reporting the statistical analysis of the measured values. The most significant violation was that the samples sent to the three laboratories (Tucson, Zurich, and Oxford) came from only one location – the lower left corner of the Shroud when it is positioned vertically. Since C¹⁴ dating requires the burning of the sample, the samples sent to the three laboratories were initially all next to each other at the lower left corner of the Shroud, so only one location on the Shroud was sampled. Other locations on the Shroud would have produced very different C¹⁴ dates according to the neutron absorption hypothesis (Ref. 20).

6C. Evidence that the Shroud is Older than 1260 AD

Of the 14 indicators for the date for the Shroud, 13 of them are consistent with the time of Jesus. Only the C¹⁴ date is inconsistent with the time of Jesus. These dating techniques are listed below starting from the technique that gives the most recent date, and then proceeding back to older dates.

1. As discussed above, samples cut from the Shroud in 1988 were C¹⁴ dated at three laboratories, with the average of the laboratory average values being 1260 AD ± 31 years. This is the raw or “uncorrected” value. When this value was corrected for the changing concentration of C¹⁴ in the atmosphere, a range of 1260 to 1390 AD was obtained (Ref. 7). This is a two-sigma range, which means that there should be a 95% probability that the true value is within this range. The one-sigma uncertainty outside of this 1260 to 1390 AD range is the same as for the uncorrected value = 31 years. Sometimes the midpoint of this range is quoted for the date of the Shroud, i.e. $(1260 + 1390) / 2 = 1325$ AD. Section 6D discusses why this conclusion results from an incomplete statistical analysis of the data.
2. The Hungarian Pray Codex or Manuscript is historically dated to 1192 to 1195 AD. It includes a painted drawing that must have been copied from the Shroud of Turin based on the pattern of burn holes on the painting and on the Shroud, so the Shroud must have existed in 1192 to 1195 AD. This is 65 years ($1260 - 1195 = 65$) prior to the range of the C¹⁴ date (1260 to 1390 AD, two sigma). Since one sigma for the C¹⁴ date is 31 years, 65 years prior to the C¹⁴ date range is an additional two-sigma ($65 / 31 = 2.1$), which means that the Shroud existing in 1192 to 1195 AD is four-sigma below the C¹⁴

date range, because the lower value of 1260 AD in the C¹⁴ date range (1260 to 1390 AD) is a two-sigma limit. Thus, the Shroud's existence in 1192 to 1195 AD, proven by this historical document, is four-sigma below the C¹⁴ date, which is far outside of the usual two-sigma acceptance criteria. And the burial cloth that was painted on the Hungarian Pray Manuscript had evidently been in Constantinople for centuries. This proves that the C¹⁴ date range of 1260 to 1390 AD should be rejected. But more importantly, it raises the following question: What could have caused the C¹⁴ date range of 1260 to 1390 AD to be so wrong? The best answer to this serious question is the neutron absorption hypothesis discussed in Section 3.

3. It is believed that the spinning wheel was invented in Asia by the 11th century and had spread to Europe by the 13th century. Since the Shroud is made of hand-spun thread, rather than thread from a spinning wheel, the threads that compose the Shroud were probably spun before the spinning wheel arrived in Israel about the 12th century.
4. The international standard of the market place at the time of Jesus was the Assyrian cubit which was equal to about 21.6 inches (54.9 cm). The dimensions of the Shroud in this unit is 7.97 by 2.02 cubits. When held up for display, the Shroud was normally held by the long side of the cloth with the lower side of the cloth hanging free. This would have caused the width to increase slightly during each such display, thus probably causing the length to decrease slightly. This means that the original dimensions of the Shroud were very likely 8 by 2 Assyrian cubits, consistent with the international standard used in the market place in the first century (Ref. 21). Thus, the size of the Shroud indicates that it was made in ancient times when the cubit was used as a unit of measurement.
5. Ancient coins that contain the same image as the Shroud of Turin go back to about 675 AD. The Shroud of Turin and the coins could not have both been copied from another item since the Shroud could not have been copied from anything for reasons given above in Section 6A. This indicates that the coins must have been copied from the Shroud, thus showing that the Shroud must have existed prior to about 675 AD.
6. The face or head cloth of Jesus that Peter and John found in the Tomb on Sunday morning after Jesus' death and burial is believed to be in Oviedo, Spain. It is called the Sudarium of Oviedo, based on the Greek word (soudarion) in John 20:7. It does not contain an image. This is evidently because it was not on the face when the body disappeared from within the Shroud. But the Sudarium does contain the same type of blood as the Shroud of Turin (human, type AB) and several researchers believe that the shape of the blood stains on the Sudarium match the locations on the head that were bleeding as indicated on the Shroud. Thus, there is good evidence that the Shroud of Turin and the Sudarium of Oviedo covered the same body. There is a definite history for the Sudarium that dates back to 570 AD in Jerusalem. It left Palestine in 614 and arrived in Spain a few years later. It went to northern Spain in 718 and was taken to Oviedo in 840 AD, where it has remained ever since. The evidence that the Sudarium and the Shroud covered the same body indicates that the Shroud can also be dated back to at least 570 AD.

7. Ancient paintings and other works of art that contain the same image as the Shroud of Turin go back to about 550 AD. For the reasons stated above, the ancient paintings must have been copied from the Shroud, so that the Shroud must have been in existence by about 550 AD.
8. The image on the Shroud is that of a crucified man. Specifics of this image indicates that it was made at a time when there was current knowledge of Roman crucifixion:
 - Paintings in the Middle Ages show the nails going through the palms, but experiments indicate that nails through the palms will not support the weight of the body due to the lack of bones above this location. The Shroud shows that the nails were in the wrist, which will support the weight of the body.
 - Paintings in the Middle Ages prominently shows the thumbs. But when the nails go through the wrist, they crush the main nerve for the hand. This would have automatically folded the thumbs under the palms. Again, the Shroud gets it right, even though it is contrary to the culture of the Middle Ages.
 - The scourge marks were consistent with the design of a Roman flagrum.
 - The side wound was the size and shape of the tip of a Roman thrusting spear.

Constantine the Great, the first Christian emperor, abolished crucifixion in the Roman Empire in 337 AD out of veneration for Jesus Christ, its most famous victim. Thus, the image on the Shroud was probably made earlier than 337 AD.

9. Ancient historical documents and traditions indicate that the burial cloth of Jesus, after being in Jerusalem, may have been taken along with other relics to Antioch in Syria prior to the destruction of Jerusalem in 70 AD, may have been in Galatia in Turkey (Galatians 3:1) in the first century, and may have been taken to Edessa in Turkey perhaps in the second centuries. It was probably taken to Constantinople in 574 AD as the Image of God Incarnate, though an alternate hypothesis is that it was taken to Constantinople in 944 as the Mandyllion or the Image of Edessa. It was in Constantinople till after 1200 AD. It was displayed about 1355 or 1356 in Lirey, France, as the burial cloth of Jesus. It has been in Turin, Italy, since 1578.
10. There is a 3.5-inch wide piece of linen that is sewn onto the main piece of the Shroud along the long side of the Shroud. According to expert opinion, the stitch used to connect this side piece onto the main piece was made by a professional and is a unique stitch. The most similar stitch is on a piece of cloth found at Masada, which was destroyed in 73 to 74 AD. Thus, this stitch on the Shroud is probably one of the best ways to date the Shroud and dates it to the first century.
11. The image on the Shroud is that of a naked man who was crucified exactly as the Bible says that Jesus was crucified. As discussed above, many evidences indicate that the image could not be due to an artist or forger. The only other option is that the body that was wrapped in the Shroud in some way made the image on the Shroud. Since no normal human body could have encoded an image of itself onto the Shroud, many Shroud researchers conclude that the Shroud must be the authentic burial cloth of Jesus.

The ancient historical texts indicate that Jesus probably died either in 30 or 33 AD, so that the Shroud must also date to 30 or 33 AD.

12. A photograph of the face on the Shroud taken by professional photographer Giuseppe Enrie in 1931 indicates a possible coin over one eye. With computer enhancement, three letters on the coin seem to be apparent. These letters and the shape of the coin may indicate that it is a Roman Lepton minted by Pontius Pilate in 29 to 32 AD. This evidence is tentative, as it is found primarily on one photograph and could be the result of the image enhancement. But with confirmation, this dating technique could become definitive.
13. Giulio Fanti developed three different types of physical tests to determine how flax fibers change with age (pages 204, 207, and 246 of Ref. 22). These tests were then applied to the Shroud to determine its age. The resulting ages are given below:
 - Fourier Transform Infrared Spectroscopy (FTIR): 300 BC \pm 400 years
 - Raman Spectroscopy: 200 BC \pm 500 years
 - Tensile strength of flax: 400 AD \pm 400 years

The stated uncertainty values are two sigma values, equivalent to a 95% probability range. The average of the three tests is 33 BC \pm 250 years for the Shroud of Turin.

14. Fibers from the Shroud show damage from sources of natural background radiation. Using microscopic analysis of the Shroud fibers, chemist Ray Rogers found that the radiation damage to the Shroud fibers indicates that the Shroud “is quite old, similar to flax fibers from the Dead Sea Scrolls” (page 5 of Ref. 30), which are dated to about 250 BC to AD 70. This indicates that the Shroud of Turin should also date to about the same period.

6D. Statistical Analysis of the C¹⁴ Measurements

Sixteen date measurements were made on subsamples by the three laboratories. The statistical analysis of this data was reported in “Radiocarbon Dating of the Shroud of Turin” by P. E. Damon + 20 others (Ref. 7). This statistical analysis was inadequate as indicated by the following:

1. Repeated measurements of a physical quantity will normally show some variation in the measured values. This variation can be due to either random variation of the measurements or a systematic bias. Since random effects might cause a measured value to be a little high one time and a little low another time, these variations from the true value will mostly cancel when the average is calculated for many measurements. But a systematic bias, since it is not random but is a function of some parameter, can cause the average of the measured values to be significantly displaced from the true value. When the C¹⁴ dating of the Shroud was done in 1988, it was well known that the continuous history of the Shroud only went back to when it was exhibited in Lirey, France, in about 1356, but the many evidences that the Shroud’s history went back several centuries

before the 14th century were not well known. As a result, those doing the statistical analysis of the 1988 measurement data probably would have assumed that the Shroud was from the 14th century, so that there was nothing unusual about the Shroud, so that it could be dated by the C¹⁴ dating methodology as any other piece of fabric. Because of this, they would have assumed that the variations in the measurements would only be due to random variations and not due to a systematic bias. Their statistical analysis, as discussed in Damon, found that this basic assumption was not true: “The underlying principle of the statistical analysis has been to assume that ... the quoted errors fully reflect all sources of error ...” with the “quoted errors”, i.e. measurement errors stated in Ref. 7, being due to only random effects. But it was concluded in Damon that “it is unlikely that the errors quoted by the laboratories ... fully reflect the overall scatter.” This is important because it shows that those doing the statistical analysis in Damon recognized that it was very likely that the measured values varied more than would be caused by the stated measurement uncertainties alone. This indicates that something strange was going on that they did not understand, such as the presence of a systematic bias that could have caused all measurements to be off. This indicates that the resulting average of 1260 AD (uncorrected) should not be accepted as necessarily valid. But instead of recognizing this, just the opposite was concluded: “These results provide conclusive evidence that the linen of the Shroud of Turin is mediaeval.” Thus, this conclusion results from an incomplete analysis of the measurement data that resulted in a failure to recognize the evidence that a systematic bias had affected measurements at all the laboratories.

2. They did not accurately communicate the measurement values. This was done by reducing the 16 measurements to 12 values by averaging four pairs of values (8 measurements) from the Tucson laboratory and then reporting it as though there were only four measurements at the laboratory in Tucson. This process eliminated Tucson’s highest and lowest values from the report so that the data appeared to be more consistent than it was. It was many years before it was revealed that Tucson had done eight measurements instead of just four.
3. Even after reducing the actual 16 measured values to the 12 reported values, the reported values for the Shroud were still so inconsistent that the analysis technique used for the Shroud had to be switched from use of a weighted mean, which was used for all three of the standards that were run at the same time as the Shroud samples, to an unweighted mean. And even then, the results of the Chi-squared statistical analysis on the 12 reported values and their associated uncertainties had to be rounded up from a significance level of 4.18% to 5% (Table 1 and 3 of Ref. 19, and Table 2 in Damon, Ref. 7) to meet the usual acceptance criteria. If they had rounded down from 4.18% to 4%, as is the common practice, then even the 12 measurement values given in the report would not pass the usual acceptance criteria of 5%, so that the accuracy of all measurement values should have been suspect. The reason for these problems in their statistical analysis appears to be that they could not conceive of any reason for a systematic bias to be affecting the measurements, and this resulted from their assumption that the Shroud was a forgery from the Middle Ages and thus not related to Jesus or the reported disappearance of his body from within the Shroud (John 20:3-9).

4. The C^{14} dates from the three laboratories are not statistically consistent with each other. When all 16 measured values are included, the average values are Oxford = 1200.8 ± 30.7 , Zurich = 1273.9 ± 23.7 and Tucson = 1303.5 ± 17.2 . The average values from the laboratories in Oxford and Tucson are statistically different. The difference, including a statistical calculation of the uncertainty, is 102.7 ± 35.2 ($1303.5 - 1200.8 = 102.7$ and $35.2 =$ the square root of 17.2 squared plus 30.7 squared). This is nearly a three-sigma difference ($102.7 / 35.2 = 2.92$), which is outside of the normal acceptance criteria of two sigma. This indicates that very likely the samples sent to Oxford and Tucson contained significantly different amounts of C^{14} . But how could they contain different amounts of C^{14} when they were both cut from the same area of the Shroud? According to the neutron absorption hypothesis (Ref. 20), the explanation is that the samples sent to Tucson and Oxford were basically different because they had different amounts of new C^{14} produced in them because of the neutron distribution in the tomb, which would have naturally taken a shifted cosine distribution in the limestone tomb (Fig. 9 in Ref. 20).

5. When a chi-squared statistical analysis is applied to all 16 measured values, with the laboratory's assumption that all measurement variation is only due to random measurement error with no systematic bias, the result is a significance level of only 1.4% (Table 6 of Ref. 19). This means that there is only a 1.4% probability that the range or spread of the measured values is consistent with the stated measurement uncertainties. This falls well below the usual minimum acceptance criteria of 5% so that the measured C^{14} dates should have been questionable. Alternatively, if the presence of a systematic bias is accepted, then the systematic bias should be identified and quantified so that the measured values could be corrected. This was not done in Damon (Ref. 7) so again the measured values should not be accepted as necessarily valid. It is not justified to simply assume that the C^{14} measurement uncertainties were underpredicted, as was done in Damon, because the measurement uncertainties were determined using the same equipment and procedures as the C^{14} measurements. The uncertainties stated in Damon are also consistent between the various laboratories and for the various standards. The average uncorrected date of 1260 ± 31 AD was obtained by assuming that the uncertainties for each of the 16 measurements could simply be ignored. All the experimental data included 32 values – the 16 measurements plus the 16 measurement uncertainties. To ignore all the uncertainties is to ignore half of the data. Thus, the 1260 ± 31 AD date was obtained by ignoring half of the data, i.e. all of the uncertainties.

6. The spatial dependence of the results is shown when the three laboratory average values (Oxford = 1200.8 ± 30.7 , Zurich = 1273.9 ± 23.7 and Tucson = 1303.5 ± 17.2) are plotted as a function of the distance from the end of the Shroud. A reasonably linear plot (Figure 6 in Ref. 18 and Figure 3 in Ref. 19) is obtained with a slope of about 36 years per cm. This means that moving the sample point on the Shroud by one cm will change the C^{14} date by about 36 years, moving the sample point by one inch (2.54 cm) will change the C^{14} date by about 91 years, and to the extent that the curve can be extrapolated, moving the sample point by 13.5 inches (34.2 cm) will shift the C^{14} date by the difference between 30 AD and 1260 AD. What could cause this slope (36 years per cm) in the C^{14} date at the sample location? MCNP nuclear analysis computer

calculations (Ref. 20) obtain a similar slope for the C^{14} date, depending on how the Shroud was folded at the feet, due to the normal distribution that neutrons take in a limestone tomb as it would have been constructed in Jerusalem in the first century. These calculations assumed that neutrons were included in the burst of radiation that was emitted from within the body that formed the image, so that the neutrons were assumed to be emitted homogeneously from within the body.

Extensive statistical analysis of the C^{14} measurement values by multiple experts (Ref. 32 to 36) confirms the analysis in Ref. 19 that is summarized in this paper. The conclusion is that the variation in the measured values was not only due to random measurement errors, which are common to all measurements, as assumed by the three laboratories, but also due to a systematic bias that would have affected all the measurements. This systematic bias, since it was not identified and quantified so that the measured values could be corrected, indicates that the C^{14} measurement results (1260 to 1390 AD with a 95% probability) should not be accepted as necessarily valid. This raises the following question: what could have caused a systematic bias sufficient to shift the C^{14} date from what is believed to be the correct year (~ 30 AD) to the range of 1260 to 1390 AD? The best explanation for this systematic bias that is consistent with everything that we know about carbon dating as it relates to the Shroud of Turin is that about 2×10^{18} neutrons were included in the burst of radiation from the body that burned the image onto the Shroud (Ref. 20). These neutrons created new C^{14} atoms on the Shroud, increasing the C^{14} atom density by about 16%, which shifted the C^{14} date in the forward direction from the first century to 1260 AD (uncorrected value).

7. Conclusion

Results of the Shroud of Turin Research Project (STURP) in 1978 indicate that formation of the image on the Shroud is not consistent with any known process. Characteristics of the image are so strange that it is most reasonable to conclude that the image cannot be man-made. The only alternative is that the image of the crucified man in some way was formed by the body that was wrapped in the Shroud. This has led most researchers to conclude that the Shroud of Turin is the authentic burial cloth of Jesus. The image consists of linen fibers that were discolored in a pattern that produces the appearance of a crucified man. The mechanism that discolored the fibers required information to control it so that the correct pattern would be produced. We see the image of the crucified man on the Shroud because the information that defines the appearance of a naked crucified man has been encoded into the pattern of discolored fibers on the Shroud (Ref. 9). This information was only inherent to the body and could only be transported from the body to the Shroud by radiation (Ref. 8). This means that the image is a radiation burn. Experiments indicate that ultra-violet light and charged particles such as protons can discolor linen fibers like those on the Shroud (Ref. 23 to 29). The presence of bones in the image indicates that the radiation was emitted from within the body.

The main objection to these conclusions is the 1988 C^{14} dating of the Shroud to 1260 to 1390 AD, but 30 years of additional research has convinced most researchers that this date range cannot be correct. There are 13 other date indicators that are consistent with a first century date for the Shroud, and careful analysis of the C^{14} measured dates indicates that they were

inconsistent with the measurement uncertainties so that they should not be trusted (Ref. 18 and 19). If neutrons were included in the radiation that was emitted from within the body, then the C^{14} date to 1260 to 1390 AD can be explained. Neutrons absorbed in N^{14} on the Shroud would create new C^{14} on the Shroud which could shift the C^{14} date forward by thousands of years. To shift the C^{14} date from 30 to 1260 AD would require only a 16% increase in the C^{14} atom density at the sample location (Ref. 20)

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Biographies

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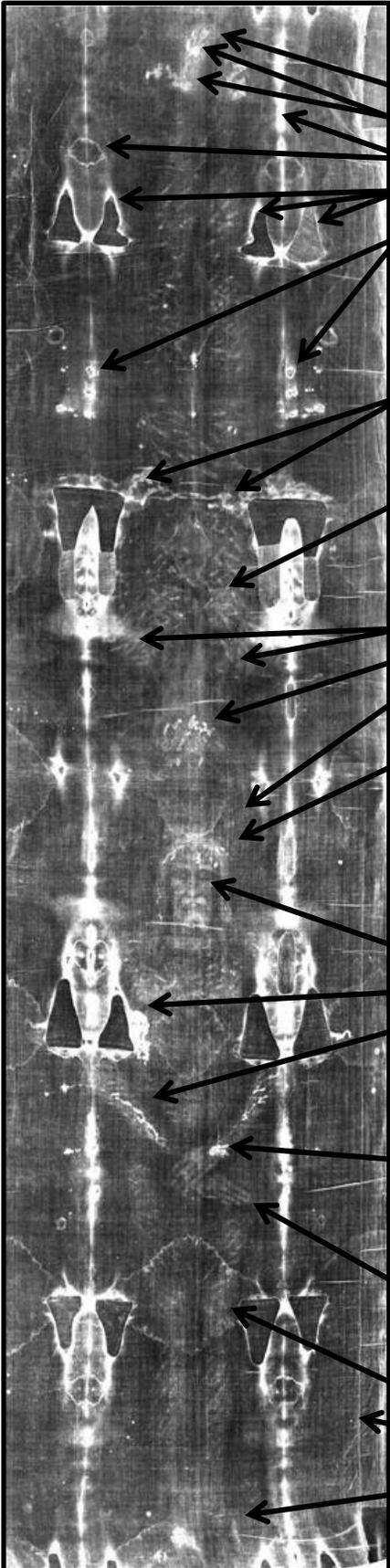


Figure 1. Front and Back Images on the Shroud of Turin

1. Rigor mortis in the feet. This indicates the victim was dead.
2. Two nails through one foot, one of them through both feet.
3. Fire in 1532 resulted in scorch marks and water stains.
4. Areas badly damaged in the fire were patched in 1534.
5. The Hungarian Pray Manuscript (1192-1195) has a painting of a famous burial cloth that had long been in Constantinople. It shows the same L-shaped burn holes that are on the Shroud, so the Shroud must have existed significantly (> 2 sigma) before the C^{14} date of 1260 to 1390 AD.
6. The Shroud appears to show a flow of blood and clear blood serum from a wound in the side. Compare with "blood and water" in John 19:34.
7. The Shroud shows 100 to 120 scourge marks from Roman flagrum. Resulting blood marks show blood serum rings (visible only under UV) around the blood exudate. Compare with Mk. 15:15.
8. Abrasions on both shoulders from carrying a rough object.
9. Puncture wounds from sharp objects that pierced his scalp.
10. Pollen on the Shroud unique to the area around Jerusalem. Pollen from a plant with long thorns found around his head.
11. The images are negative images and contain 3D information that indicates the distance of the cloth from the body. Only the top 1 or 2 layers of fibers in a thread are discolored. The discolored fibers in the image result from the carbon atoms that were already in the cellulose molecules in the flax fibers being changed from single to double electron bonds.
12. Swollen cheeks and damaged nose from a beating or a fall.
13. Side wound shows a hole the size of a Roman thrusting spear.
14. Blood running down arms at the correct angles for crucifixion. Blood is real human blood, male, type AB. The blood with high bilirubin content and nanoparticles of creatinine bound to ferritin prove he was severely tortured.
15. All paintings from the Middle Ages show nails through the palms, but this will not support sufficient weight since there is no bone structure above this location. The Shroud shows the correct nail locations - through the wrist instead of the palm.
16. Shroud correctly shows thumbs folded under due to contact of the nail with the main nerve that goes through the wrist. This is also contrary to paintings from the Middle Ages.
17. Abrasions on one knee show a microscopic amount of dirt.
18. Three-inch wide side strip sown on with a unique stitch very similar to that found at Masada (destroyed in 73-74 AD).
19. Microscopic chips of travertine aragonite limestone containing impurities that closely match limestone in Jerusalem.