

Explaining the Mysteries of the Shroud

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Abstract

To determine whether the Shroud of Turin could be the authentic burial cloth of Jesus, the many mysteries related to the Shroud need to be explained with a logically consistent unbiased evidence-based approach that follows the evidence where it leads. This is attempted in this paper based on information, radiation, and neutron absorption. Why we can see the image on the Shroud is explained by the presence of information in the pattern of discolored fibers in the image. Formation of the image is explained by radiation emitted from within the body that communicated the required information to the Shroud to form the image. The carbon dating of the Shroud to 1260 to 1390 AD is explained by neutrons that were apparently included in this radiation. A small fraction of these neutrons would have been absorbed in N^{14} in the Shroud to form new atoms of C^{14} in the Shroud. This would have shifted the carbon date forward by up to thousands of years, depending on the location. The man, who was crucified and whose body emitted radiation, is best understood to be Jesus.

1. Introduction

This paper presents a sequential approach to explain the mysteries related to the Shroud of Turin. According to tradition, the Shroud is the authentic burial cloth of Jesus that was discovered by Peter and John in the tomb on the Sunday morning following Jesus' crucifixion. To determine whether this could be true, more historic and scientific research has been done on the Shroud than on any other ancient object.

According to research on documents, traditions, coins, artistic works, pollen, and DNA (Ref. 15) the following is the most likely history for Jesus' burial cloth (Ref. 16 to 20). Jesus' burial shroud was found by Peter and John in the tomb after Jesus' crucifixion in Jerusalem (John 20:3-9). Galatians 3:1 (~ 47 to 56 AD) indicates that the believers in Galatia had been shown something that "clearly" or "publicly portrayed" "Jesus Christ ... as crucified" (NIV & NASB). The Greek word translated "portrayed" in this verse, "prographa", is one of the sources of our English word "graphic" and can be translated as "signboard" (NLT) or "placard" (Wuest). Based on the meaning of this Greek word and the context in the sentence, this was a physical object that contained an image of Jesus that showed that he was crucified. They had seen it with their "very eyes" (NIV). The most obvious explanation is that they saw Jesus' burial Shroud containing his image, as on the Shroud of Turin.

In the first century, Antioch was the third largest city in the Roman Empire next to Rome and Alexandria in Egypt (Page 9 of Ref. 16). Many of the early believers, when they fled Jerusalem to avoid persecution, went to Antioch (Acts 11:19) so that it became the center for Christian outreach (Acts 11:26, 13:1). A tradition preserved in the writings of Athanasius (298–373 A.D.) indicates that prior to the destruction of Jerusalem in 70 AD, Christian relics, including the icon of our Lord, were brought from Jerusalem through Pella to Syria, perhaps Antioch. Ancient texts and an inscription indicate that Jesus' shroud may have been involved in the conversion of King Abgar the Great of Edessa in Mesopotamia probably in the second century.

The image that is now on the Shroud of Turin was frequently copied in Byzantine art, the earliest surviving example being the Christ Pantocrator painting from St. Catherine's Monastery at Sinai, which probably dates to about 550 AD (pages 2 and 17 to 18 of Ref. 16). The Shroud was most likely brought to Constantinople, the capital of the Byzantine Empire, in 574 as the Image of God Incarnate. An alternate theory is that it was brought to Constantinople in 944 as the Mandyllion or Image of Edessa (Ref. 21 and 22). Its presence in Constantinople long before the C¹⁴ date (1260 to 1390 AD) is confirmed by Byzantine coins starting in 692, the Hungarian Pray Manuscript (1192-1195 AD), and the report (1203-1204 AD) of French crusader Robert de Clari that it was exhibited weekly at the Church of St. Mary in the Blachernae district of Constantinople. It may have been sold by Byzantine emperor Baldwin II to his cousin, King Louis IX of France, between 1237 and 1261. Others believe it may have been stolen from Constantinople in the sack of the city in 1204. In about 1355 it was exhibited in Lirey, France, as the true burial cloth of Jesus by the French knight Geoffrey de Charny, the grandson of Jean de Joinville, a principle adviser to King Louis IX. In 1453, it was sold by Geoffrey de Charny's granddaughter to Louis, the Duke of Savoy. It was then gradually transported across France till it came into Turin, Italy, in 1578. The following is thus indicated:

- The Shroud of Turin has a long history before the C¹⁴ date of 1260 to 1390 AD.
- There is no historical evidence that precludes the Shroud of Turin from being the authentic burial cloth of Jesus.
- The uncertainties in the above sequence means that the historical quest does not currently prove that the Shroud of Turin is the authentic burial cloth of Jesus. However, there are legitimate options within the above sequence that the Shroud of Turin may be the same cloth that Peter and John found when they entered the tomb in Jerusalem.
- The historical evidence, when combined with the results of the scientific investigation of the Shroud, is sufficient to convince most Shroud researchers that the Shroud of Turin is very likely the authentic burial cloth of Jesus.

But is it possible that Jesus' burial shroud could still be in existence? According to early historical records related to Jesus' burial shroud (John 20:1-9), it was found by Peter and John in the tomb on the morning of the third day after he was crucified, so that Jesus' burial shroud certainly did exist at one time. Most people naturally want to save items that remind them of important events in the past, but even Jesus' clothing was stripped from him prior to his crucifixion. The only things left behind by Jesus were his burial shroud and the cloth that covered his face (John 20:7). Jesus' earliest disciples would have regarded his burial shroud as extremely important because it was part of the basis for their belief in Jesus' resurrection and because it had Jesus' blood on it, even if the image did not develop until months or years later due to aging and exposure to sunlight. It seems very unlikely they would have reused it, burned it, or thrown it out. And it seems very likely they would have tried to prevent it from being intentionally destroyed. Due to persecution, Jesus' disciples probably would have kept their possession of the shroud a secret. If kept away from insects, moisture, fire, and intentional destruction, Jesus' burial shroud should still be in existence since linen naturally decays only by dehydration and oxidation of the linen fibers. This is a very slow process, which is why museums have many examples of linen that are thousands of years older than the Shroud of Turin. And if Jesus' burial shroud were still in existence, considering the last 2000 years of church history, the most likely place to find it would be in association with the Catholic church.

Thus, the Catholic cathedral in Turin, Italy, is a very reasonable place to find Jesus' burial shroud. The possibility of the Shroud being the authentic burial cloth of Jesus should not be rejected just because it is now located in a Catholic cathedral. To do so is to commit what in logic is called a "genetic fallacy" – making a conclusion based solely on something's origin, source, or location (Ref. 27).

Scientific research on the Shroud (Ref. 5) has focused on discovering the scientific evidence related to the Shroud so that a comprehensive hypothesis could be developed to explain the many mysteries of the Shroud. This is called forensic science, and is the method used by detectives to solve a crime scene. The key to this method is to follow the evidence where it leads, while trying to set aside biases and presuppositions, such as a presupposition of naturalism. The goal of both the historical and scientific research is to determine whether the Shroud of Turin could be the authentic burial cloth of Jesus. To answer this question, the mysteries related to it need to be understood. The main mysteries are:

- Why can we see the image on the Shroud?
- How was the image formed?
- Why did carbon dating date the Shroud to 1260 to 1390 AD?

Note that why we can see the image and how the image was formed are two different questions, though they are related. To answer the above questions, the discussion in this paper is arranged in the following logical sequence:

1. We can see the image on the Shroud because the information that defines the appearance of a crucified man is encoded into the pattern of discolored fibers in the image.
2. This information must have been deposited on the Shroud.
3. Prior to being deposited on the Shroud, this information was only inherent to the body that was wrapped in the Shroud.
4. This information had to be transported from the body to the Shroud in some way.
5. Of the six possible means of transporting information from one location to another, five of them could not apply to forming the image on the Shroud, so the only remaining option to transport the required information from the body to the Shroud is radiation.
6. It's most reasonable to believe that this radiation was emitted from within the body.
7. If neutrons were included in this radiation, then the four things that are known about carbon dating as it relates to the Shroud can be explained. This includes the carbon dating of the Shroud to 1260 to 1390 AD.
8. The best explanation for this radiation being emitted from the body of a crucified man is that the man was Jesus, and the event was his disappearance from within his burial shroud.

Based on these explanations, other mysteries related to the Shroud can be explained.

2. Why can we See the Image on the Shroud?

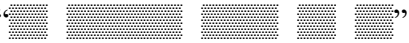
The Shroud of Turin contains good resolution images of the front and back of a naked man that was crucified exactly as the New Testament describes that Jesus was crucified (Figure 1 and Ref. 6). The image and blood indicate that this man was dead. This is indicated by several evidences including the rigor mortis that is evident in the shape of his feet and by the postmortem wound in his side. This wound occurred after death because there is no swelling, the blood flowed due to gravity instead of pressure from a beating heart, and the presence of the large amount of blood due to the spear evidently piercing the right auricle which fills with blood upon death.

The image on the Shroud consists of human blood and discolored fibers in the linen threads. Details of the mechanism that discolored the fibers are not understood. But the discoloration mechanism would have required two things – energy to drive it and information to control it. Information was necessary to control which fibers would be discolored and the length of discoloration on each fiber so that the image could be formed (Ref. 7). To understand why we can see an image on the Shroud, the nature of information needs to be understood.

Physics might be defined as the study of how our reality operates. In previous centuries, the study of physics centered on three quantities – mass, space, and time. In the development of physics, researchers gradually came to understand that another quantity called energy was also useful to understand reality. In a simplistic explanation, energy might be thought of as a quantity related to a mass moving through space as a function of time, for example the kinetic energy of a moving body is equal to one-half times its mass times its velocity squared [$E = \frac{1}{2} (mv^2)$]. Over the last few decades, another useful quantity that relates mass, space, and time has been recognized. This is the concept of information. For example, the information in our DNA is contained in the sequence of molecules in the DNA chain. This information controls the shape of proteins that are necessary for life to exist. There is also information communicated by electrons flowing in electrical wires that allows our computers to function. Light can also communicate information, as in thin glass or plastic wires bundled into fiber-optic cables. Our recent recognition of the importance of information has caused people to call our current age the information age. In our study of the Shroud, two aspects of information need to be understood: 1) why information is essential to every image, and 2) how information can be transferred from one location to another. Two examples will be considered to help explain the nature of information – a sentence and a photograph.

A sentence includes information. A random sequence of letters and punctuation (er osWras de.e oh re) makes no sense, but when the letters and punctuation are put into their proper sequence (She wore a red rose.), it makes sense. The difference is that the sequence of letters and punctuation in the sentence “She wore a red rose.” contains information whereas this information is missing in “er osWras de.e oh re”. Unfortunately, information is not something that is easily measured to determine the quantity of information that is present. But we can easily determine that information is present when we read the sentence and it makes sense to us.

There is also a deeper sense in which information is present in “She wore a red rose.” In general, each letter consists of a pattern of black dots called pixels. For example, if the sentence is found

in a newspaper or a computer monitor, the black dots that make up the image of each letter or punctuation mark can be seen in a microscope. The information is that which defines the locations of the dots or pixels in the pattern that forms the letter. The information that is necessary to form the appearance of one letter is different than the information that is necessary to form another letter. This means that the sentence “er osWr as de.e oh re” contains more information than “” though there may be the same number of black dots in each “letter” of each sentence. Thus, in the sentence “She wore a red rose.” there is information in the sequence of letters and punctuation, but also in the pattern of black dots that form the individual letters and punctuation marks.

Just as the pattern of dots that form the letters includes information, a photograph also includes information in a pattern of dots. Whether a black-and-white or a color photograph, the pattern of dots or pixels that makes up the image contains information. It is information that specifies where the dots or pixels ought to be located that determines the appearance of the image. The information that is contained in the pattern of dots is that which defines the appearance of the image so that we can have a conscience perception of that appearance. This process requires something to carry, transfer, or communicate this information from one location to another. When a woman’s picture is taken, the information that defines her appearance is inherent to her body and her clothing. For the camera to take the photograph, a copy of this information that defines her appearance must be carried from her to the camera. This is accomplished by the light that is reflecting off her.

Visible light is a form of radiation. The smallest unit or packet of visible light is called a photon. All photons of light have three important characteristics: energy, intensity (number of photons), and direction. These characteristics of photons can communicate information from one location to another. The energy of a photon can communicate color. The intensity or number of the photons can communicate the shade - light versus dark. And the direction of the photons as they enter the lens of the camera can communicate the position of the point on the item that has the color and shade. Thus, the photons of light that reflect off the woman, by their energy, intensity, and direction, communicate to the camera all the information that defines her appearance.

This information that defines her appearance (colors, shades, and positions) is then deposited on and encoded into the film or digital card in the camera. Later, either light is used to communicate this information from the camera’s film to the photographic paper, or electronics is used to transfer the information from the digital card to the photographic paper. The information that defines her appearance is then encoded into the pattern of dots that make the image on the photographic paper. When we look at the resulting image, photons of light are reflecting off the picture in all directions, including toward our eyes. These photons communicate the information from the picture to our eyes. When these photons of light enter our eyes, they deposit the information on the rods and cones at the back of our eyes. The rods and cones translate this information into electrical signals that travel up our optic nerves to our brains. Our brains have learned to properly interpret the information in these electrical signals so that we can have a conscious awareness of the appearance of the woman in the picture.

The above can be generalized. Every meaningful image that we see is the result of information encoded into the image in some way. The important point is that this applies to the Shroud of

Turin. We conclude that we can see the image of a crucified man on the Shroud because the information that defines the appearance of a crucified man has been encoded into the pattern of discolored fibers on the tips of the linen threads that form the image on the Shroud. When photons of light reflect off the Shroud and enter our eyes, this information is communicated from the Shroud to the rods and cones at the back of our eyes, which translate it into electrical signals that travel up our optic nerves to our brains. Our brains have learned to interpret this information in the electrical signals as the appearance of a crucified man.

3. How was the Image Formed?

The information that defines the appearance of a crucified man had to be encoded into the pattern of discolored fibers that make up the image. But how was this encoding process accomplished to form the image? In 1978, the Shroud of Turin Research Project (STURP) was allowed by officials in Turin to send about 26 scientists to Turin, Italy, to do hands-on scientific examination of the Shroud for five days, 24 hours a day. Their main objective was to determine how the image was formed. Scientific testing done during this period together with subsequent analysis indicates the following:

1. The image has no pigment, no carrier, no brush strokes, no clumping of anything between the fibers and threads, no cracking of the image at the fold points, and no evidence of capillarity – soaking up of a liquid. This means that the image can not be due to paint, dye, stain, or any liquid.
2. The temperature gradient due to the fire in 1532 did not alter the intensity of the fiber's discoloration so the image is not due to any organic or inorganic chemical.
3. The image does not fluoresce under ultraviolet light, so it is not a scorch due to contact with a hot object.
4. No light sensitive chemicals are present, so the image is not a photograph.
5. No body decay products were found on the cloth, so the image was not caused by decay of the body.
6. The image is not visible in back lighting, so it is not due to any substance added to the cloth.
7. There are about 100 to 200 fibers in a linen thread but only the top one or two layers of fibers are discolored. The fibers internal to the thread are not discolored.
8. Linen fibers have a diameter of about 20 microns but only the outside surface of a fiber is discolored. The thickness of this discoloration is only about 0.2 microns (micron = a millionth of a meter). This thickness of discoloration is thinner than a wavelength of light and is 360 degrees around the outside of the fibers with the inside of the fiber not discolored at all.
9. All discoloration of the fibers is of the same intensity of sepia or straw-yellow coloration. The smooth changes in the intensity of the image that is apparent to the human eye is due to the number of fibers that are discolored and the length of that discoloration on the fibers. Since the discoloration on a fiber is the same for the front image as for the back image, the discoloration mechanism must be independent of weight. This is because the front image was formed with only the weight of the cloth on the body whereas the back image was formed with the weight of the body on the cloth.

10. The fibers that are discolored in a thread are not discolored uniformly across the thread but are grouped together, forming striations.
11. This extremely thin discoloration layer on a fiber is caused by a change in the electron bonds of carbon atoms that were already in the cellulose molecules of the flax fibers.

To further explain this last point, each carbon atom has four electrons in its outer orbit that are used to bind it to the surrounding atoms in a molecule. In the cellulose molecule in the flax fiber, each of these four electrons bind each carbon atom to one other atom, so that each carbon atom is bound to four atoms around it. This allows each carbon atom to vibrate in a certain way, which causes light to reflect from it to produce the normal color of the linen fibers. The discoloration of the fiber occurs when the arrangement of the atoms in the cellulose molecule are altered so that some of the carbon atoms are only surrounded by three atoms, with one of the outer orbit electrons binding it to the first atom, one electron binding it to the second atom, and two electrons binding it to the third atom. This new arrangement causes the carbon atom to vibrate in a different manner, which causes it to reflect light differently, which causes the fiber to have a sepia or straw-yellow appearance. In other words, the discoloration is caused by some of carbon's single electron bonds being changed into double electron bonds. This discoloration of linen fibers can be caused over long periods of time by dehydration and oxidation, but on the Shroud, the fibers had to be discolored in a pattern to form the image of a crucified man.

There is no known way that an artist or forger could have formed an image with the above characteristics in any era, past or present. The technology to do this has never existed. An important question now arises in the logical sequence in this paper. There are two options as to how to proceed:

- The first option is to make a naturalistic assumption. A naturalistic assumption is to assume that the image was made by a process that is within our current understanding of science. Though the above characteristics of the image appear to make it impossible that the image was made by any human or by any naturalistic process, this option assumes that it was nevertheless formed by a process that is within our understanding of the laws of science. Against such a naturalistic presupposition is the evidence of the extreme uniqueness of the characteristics of the image on the Shroud. If made by an artist or forger in some unknown way, then his technique shows no resemblance to anyone else's technique before or after him, and he never made anything else that even hinted at the same technique. If made by a naturalistic process without human involvement, then why is the Shroud the only example of an image of a person being naturally encoded onto a piece of cloth? With multiple billions of people living and dying in the history of mankind, while wearing clothing or being covered by a sheet, there should be other examples of such an image if it occurred by a naturalistic process. Why should such a naturalistic process without human involvement produce the image of a crucified man that was crucified exactly as the Bible says that Jesus was crucified? The scientific investigation of the Shroud began in 1898 when Secondo Pia first photographed it. In the last 120 years of further research, no explanation based on naturalistic presuppositions has been consistent with all the image characteristics. In addition, all attempts to reproduce how the image was formed, either with or without human involvement, have failed to produce the image's unique characteristics. Even if there was a copy-cat

crucifixion in Jerusalem, i.e. someone was crucified to duplicate how and where Jesus was crucified, there would still be no mechanism within our understanding of science for the dead crucified body to produce an image of itself on a piece of cloth.

- The second option is to realize that the uniqueness of the image forces us into a new worldview or paradigm that includes new concepts or thought patterns that are beyond or outside of the usual presupposition of naturalism. Such a paradigm shift is often difficult for people to consider but appears to be necessary in this case. Because the Shroud of Turin is the only known example of a human body creating an image of itself on a piece of fabric, there have been no known scientific experiments duplicating this phenomenon. In other words, to explain the mysteries of the Shroud requires that we be open to adding new concepts to our understanding of physics. As indicated in the first option, the evidence indicates that it appears to be impossible for the image to have been formed by an artist, a forger, or any natural process. The only other option is that the image was formed by the body that was wrapped within the Shroud by a process that is outside or beyond our current understanding of the laws of science. Characteristics of the blood marks on the Shroud, though they have not been considered in detail in this paper, also appear to require that they were formed by a real human body that was wrapped within the Shroud, and that the blood that was dried on the body was transferred from the body to the cloth by an unknown process. The process used in this paper is to follow the evidence where it leads while avoiding presuppositions if possible, so this second option is selected as the better option. This option allows us to follow the evidence where it leads in subsequent considerations.

The conclusion in Section 2 is that the information that defines the appearance of a crucified man has been encoded into the pattern of discolored fibers that make the image. This information must have been deposited on the Shroud for it to be encoded into the image. When this is realized, the next logical questions are where did this information come from and how was it transported to the Shroud? If the body wrapped in the Shroud was in a tomb, the information that defined the appearance of a crucified man was not inherent to the walls of the tomb, or inherent to the air in the tomb, or initially on the cloth that wrapped the body. This information was only inherent to the body that was wrapped in the Shroud, for that is what allowed people to see it as a crucified body. Thus, the information that defines the appearance of a crucified man had to be communicated from the body to the cloth so that it could be encoded into the pattern of discolored fibers in the image. But how could this information be carried, transferred, transported, or communicated from the body to the cloth? There are six ways that information can be communicated from one location to another (Ref. 7).

1. Radiation such as light or subatomic particles.
2. A flow of particles in physical connections, such as the flow of electrons in wires.
3. Direct contact as when your finger hits a key on a piano or a computer keyboard.
4. Waves in a medium such as sound waves in air.
5. Diffusion of molecules such as the taste of an orange or the smell of a skunk.
6. A pulse in a field such as an electrostatic field or a gravitational field.

However, five of the above could not have been involved in forming the images on the Shroud:

- Electron flow in wires did not cause the image because there were not wires or any other physical connections connecting every point on the body with every point on the image.
- Direct contact did not cause the image because there is discoloration of the fibers even where the cloth would not have been touching the body such as next to the tip of the nose, beside the hands, or on the back side of the knees.
- Sound waves did not cause the image because they spread out rapidly so could not form an image with such good resolution.
- Diffusion of molecules did not cause the image for the same reason.
- Electrostatic and gravitational fields did not cause the image for the same reason.

The only remaining option that could transfer the required information from the body to the cloth is radiation. Radiation is ideally suited to carry this information by its energy, its intensity (number of particles), and its direction. Radiation should not be thought of as something strange because photons of light, which is radiation, is how we received the information into our eyes that allows each of us to see the scene in front of us.

Could the radiation have been emitted somewhere other than in the body? For example, some individuals hypothesize that radiation was emitted in the limestone as the result of an earthquake or a nearby lightning strike. But radiation emitted in the limestone could not communicate the required information from the limestone to the Shroud, because the information required to form the image is that which defines the appearance of a crucified man. This information was not in the limestone but was only inherent to the body. If the radiation was emitted in the limestone, the radiation would have to pass through the Shroud without forming an image, and then enter the body. It would then have to pick up the information related to the appearance of a crucified man, and then in vertically collimated directions both up and down transfer that information to the cloth and deposit it there. This is a very complex process with multiple aspects that seem unexplainable, so will not be considered further. It is concluded that the best explanation for image formation on the Shroud is that radiation was very likely emitted from the body as it was wrapped within the cloth. Multiple reasons are given for this view in Ref. 8. This means that the image is a radiation burn, caused by the radiation damaging the molecules in the flax fibers. This is like a sunburn, which is caused by excessive ultraviolet radiation damaging the molecules in a person's skin.

It can also be determined that the radiation that formed the image on the Shroud had to be emitted not just from the surface of the body but from within the body. This is because bones show on the Shroud, such as teeth and bones in the hands. Some researchers have also identified bones in the skull and the bottom of the backbone. The radiation had to be emitted from within the body because the information regarding the presence of these bones had to be carried by the radiation from the body to the cloth. The duration of the radiation is indicated by laser experiments by Paolo Di Lazzaro (Ref. 9 to 13). He found that the energy had to be delivered to the linen in an extremely short burst to discolor just the top one or two layers of fibers without discoloring deeper layers of the fibers in the threads.

It is not yet clearly understood what types of radiation were involved in forming the image, or the details of the mechanism that discolored the fibers. But experiments have shown that linen

fibers can be discolored to look like those on the Shroud, including the discolored fibers arranged in striations, either by ultraviolet light (Ref. 9 to 13) or by protons (Ref. 14 and 15). Ultraviolet light can discolor linen by a photo-chemical reaction. Charged particles such as protons can discolor linen either directly or by causing a static discharge such as a corona discharge from the tips of the fibers. Other types of radiation such as gamma rays, X-rays, or neutrons would not have been involved in image formation because they are far too penetrating. If they had formed the image on the side of the cloth that was facing the body, i.e. on the inside of the wrapped configuration, then the image would have been just as strong on the other side of the cloth, i.e. on the outside of the wrapped configuration. The evidence from the Shroud contradicts this, so that gamma rays, X-rays, and neutrons are not a significant cause of the images. Additional understanding of the discoloration mechanism requires further research. However, based on radiation emitted from within the body forming the image, other mysteries can be explained:

- Why are there front and back images on the Shroud but not side images?

To create the front and back images with good resolution, there must have been a one-to-one vertical relationship between each point on the cloth and each point on the body. Two explanations have been proposed for this. The first is the cloth collapse concept (Chapters 11 and 12 of Ref. 16) which proposes that when the body quickly disappeared from within the Shroud, the cloth collapsed due to gravity and air pressure difference. When the cloth above the body moved down, and the cloth below the body moved up, they entered the region that was previously occupied by the body where they encountered radiation, which discolored the fibers. But if the air pressure difference was sufficient to cause the cloth below the body to move up, it would also be sufficient to cause the cloth at the sides of the body to move into the region where the body had been. This is because the force resulting from the air pressure difference is not vertical but is perpendicular to the cloth. According to this concept, this should have caused side images of the body on the Shroud, which is contrary to the evidence (Ref. 17). The second option is that when the radiation was emitted from within the body, it was emitted only in vertically collimated directions – both vertically up and vertically down. This vertical collimation of the radiation appears to be necessary to explain why there are no side images on the Shroud and why the front and back images have such good resolution.

- Why does the image include 3D information related to the vertical distance of the cloth from the body?

The information related to the vertical distance of the cloth from the body would be communicated to the Shroud if the intensity of the radiation were decreasing as it traveled vertically across the gap between the body and the Shroud. There are three natural mechanisms – scattering, absorption, and decay, that could decrease the intensity of the radiation as it traveled across the gap between the body and the Shroud. One of the beauties of the radiation hypothesis for formation of the image is that this 3D effect can be explained using these natural mechanisms.

- Why is the image a negative image?

With the intensity of the radiation decreasing as it travels across the gap between the body and the Shroud, it would naturally be most intense where the cloth was touching the body, for example at the tip of the nose. At this location, it would cause the most intense discoloration of the fibers, and hence the darkest image. Where the air gap between the body and the cloth is more significant, for example at the eye sockets, it would create a lighter image due to the reduction of the intensity of the radiation as it travels across the air gap. Thus, due to radiation emitted from within the body, the image would be dark at the tip of the nose and the image would be light at the eye sockets. This is just the opposite of how a face appears in natural reflected light. The tip of the nose appears light because it is out in an exposed position where it readily reflects light, but the eye sockets, since they are recessed under the eye brows, reflect less light. Thus, due to light reflected off the body, the tip of the nose would be light, and the eye sockets would be dark. This means that the light and dark areas are reversed for radiation emitted from within the body compared to natural light reflected off the body. This reversal of light and dark areas creates the apparent negative image on the Shroud.

- Why is the discoloration only on the top one or two layers of fibers in the thread, and only on the outside 0.2 microns of the 20-micron diameter of the fibers?

These characteristics of the discoloration in the fibers indicates that there was no evidence of capillarity (soaking up of a liquid) in the fibers or threads. This indicates that the discoloration was not due to use of any liquid. But this extremely thin discoloration layer could have been caused, for example, by an electrical discharge from the outer surface of the fibers due to an extremely brief pulse of charged particles hitting the fibers. This pulse of charged particles might cause an extremely high current flow in the top layers of fibers, which heats them, which discolors them. This could be compared to a “lightning rod effect” where lightning from a storm cloud hits the top of a lightning rod, producing tremendous heat. More research is needed on this topic.

- The discoloration on the fibers is due to a change in the electron bonding of the carbon atoms that were already in the cellulose molecule of the flax fibers. How could this happen?

Energy would have been required to change the electron bonding of the carbon atoms in the cellulose of the flax fibers. But since the electron bonding was changed for the carbon atoms that were already present, no new atoms were required to make this change. A burst of energy that was deposited on the Shroud but without new atoms being deposited is consistent with the hypothesis that radiation emitted from within the body formed the image, because radiation involves the transfer of energy without the transfer of atoms.

It is concluded that the image was encoded onto the Shroud by an extremely short burst of radiation (possibly ultraviolet and/or charged particles such as protons) emitted from within the body that was probably vertically collimated both up and down.

4. Why did Carbon Dating Date the Shroud to 1260 to 1390 AD?

In 1988 samples were cut from the lower corner of the Shroud and sent to three laboratories for carbon dating. These laboratories were in Tucson in Arizona, Zurich in Switzerland, and Oxford in England. The average date from the three laboratories was 1260 AD. When this value was corrected for the changing C¹⁴ concentration in the atmosphere, a range of 1260 to 1390 AD was obtained. This is a “two-sigma” range, which means that there is a 95% probability that the true date would fall within this range. This resulted in the conclusion that “The results provide conclusive evidence that the linen of the Shroud of Turin is mediaeval” (Ref. 18). But 30 years of additional research has convinced most Shroud researchers that this conclusion is badly flawed (Chapter 14 of Ref. 16). The four categories of evidence for this are:

- The impossibility of forming the image on the Shroud between 1260 and 1390 AD.
- The procedures used by the C¹⁴ dating laboratories violated the internationally established protocols for C¹⁴ dating of the Shroud.
- Many evidences indicate that the Shroud is much older than the C¹⁴ date. Of the 14 indications of the Shroud’s date (Ref. 5), 13 are consistent with a first century date and inconsistent with the C¹⁴ dating to 1260 – 1390 AD.
- Detailed statistical analysis of the C¹⁴ 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 this systematic bias can be quantified to correct the measured values, the measurement data should not be accepted as necessarily valid.

These four categories of evidence are discussed in Ref. 21 and in Section 6 of Ref. 5.

Several hypotheses have been proposed to explain how the Shroud could have been carbon dated to 1260 to 1390 AD when there is so much other evidence that its date should be consistent with the first century. In their historical sequence, these proposals have included:

1. Neutron absorption,
2. Unintentional contamination by handling,
3. Intentionally placing a material onto the Shroud such as wax or talc,
4. Smoke from the fire in 1532 being absorbed onto the Shroud,
5. High temperature from the fire in 1532 causing a change in the isotopic ratio for C¹⁴,
6. Growth of bacteria causing a plastic coating on the fibers,
7. An invisible patch or reweave of the Shroud at the sample location, and
8. Carbon monoxide at a different C¹⁴ isotopic ratio being deposited onto the Shroud.

It should be noted that the first hypothesis proposed to explain the carbon dating of the Shroud to 1260 to 1390 AD was neutron absorption (Ref. 19). The best hypothesis as to why carbon dating produced this date range should be consistent with the four things that we know about carbon dating as it relates to the Shroud:

1. The sample location on the Shroud dated to an average uncorrected value of 1260 AD.

2. The average carbon dates from the three dating laboratories, when plotted according to distance of the samples from the end of the Shroud, show a slope or gradient to the dates of about 36 years per cm.
3. The range of the 16 measurements by the three laboratories was 1155 AD to 1410 AD.
4. The Sudarium of Oviedo, which is believed to be Jesus' face cloth and thus associated with the Shroud, was carbon dated to 700 AD.

Nuclear analysis computer calculations performed in 2014 and presented at the Shroud conferences in St. Louis (Ref. 20) and Pasco, WA (Ref. 23), showed that the neutron absorption hypothesis is consistent with all four of the above evidences. The neutron absorption hypothesis (Ref. 21 to 23) is that neutrons were included in the burst of radiation that was emitted from within the body that formed the image. A small fraction of these neutrons would have been absorbed in the trace amount of N^{14} on the cloth to form new C^{14} on the Shroud primarily by the ($N^{14} + \text{neutron} \rightarrow C^{14} + \text{proton}$) reaction. Since carbon dating is done by measuring the amount of C^{14} in a sample, this new C^{14} produced on the cloth could shift the carbon date by up to thousands of years, depending on the location. The shift in the carbon date for the 1988 sample location from about 33 AD to 1260 AD would require only a 16% increase in the C^{14} concentration on the samples.

Only the neutron absorption hypothesis is consistent with all four of the above evidences. Currently, the most popular hypothesis to explain the carbon date of 1260 to 1390 AD is the invisible patch or reweave hypothesis, but this hypothesis is consistent with only the first two of the above four evidences, i.e. the date and slope. The laboratory's random cutting of subsamples from the samples should have resulted in about four of the 16 subsamples being only old material which should have dated to about 33 AD, and about four of the 16 subsamples should have been only new material which should probably have dated more recently than 1410 AD. This means that the invisible reweave hypothesis is not consistent with the range of the carbon dates (1155 AD to 1410 AD). The invisible reweave hypothesis can also not explain why the Sudarium of Oviedo dated to 700 AD. There are many other evidences why the invisible reweave hypothesis is not a credible explanation for the carbon date (Chapter 9 of Ref. 16 and Section 2 of Ref. 23). For these reasons, the neutron absorption hypothesis ought to be the preferred explanation for the 1988 carbon date of 1260 to 1390 AD. This neutron absorption hypothesis can be easily tested by carbon dating of the fully carbonized material (burned linen) that was removed from under the patches in 2002. This material now resides in glass sample vials in Turin. The nuclear analysis computer calculations predict that the carbonized material from under the patches near the elbows should date to about 4000 AD, well into the future, because of the excessive C^{14} produced at these locations by neutron absorption.

In the previous section it was concluded that the image was apparently formed by a burst of radiation emitted from within the body as it was wrapped in the Shroud. When this concept is understood and believed, it becomes easier to believe that neutrons could have also been emitted from the body because of the large number of neutrons in a human body. The atoms in a human body include protons, neutrons, and electrons. Using the weight percent of the various elements in a human body, the number of neutrons in a body can be calculated. The weight of the body that was wrapped within the Shroud is estimated to be about 77.1 kgs (170 pounds) to 79.4 kgs (175 pounds). The number of neutrons in a body of 77.1 kgs (170 pounds) is about 2×10^{28} . The nuclear analysis computer calculations discussed previously determined that if 2×10^{18}

neutrons were emitted from the body, it would be sufficient to cause the carbon date for the 1988 samples to be shifted from 33 AD to 1260 AD. This is only one neutron emitted for every ten billion (1×10^{10}) that were in the body. It should also be recognized that the nuclear forces that normally bind neutrons within the nuclei of the atoms in the body would have to be overcome in this scenario, and that the neutrons may not have been the primary particle emitted. They may have resulted from other types of radiation.

5. Is the Shroud of Turin the Authentic Burial Cloth of Jesus?

As far as known, no human body wrapped in any fabric has ever produced a recognizable image of itself on the fabric, whether the body was alive or dead. With billions of people that have lived and died wearing clothing and being wrapped in fabric, this is a significant fact. The only exception is the Shroud with its image of a crucified man. According to the above analysis, the image on the Shroud was formed by a burst of radiation emitted from within the body. But in our modern experience, no human body has ever emitted such a burst of radiation that could burn an image of itself onto fabric. Thus, according to the laws of physics as we currently understand them, there appears to be no mechanism for a human body to do this. Yet the Shroud tells us that it has happened. To resolve this apparent contradiction, we need to be willing to follow the evidence where it leads, even if it contradicts our presuppositions. The main conclusions from the previous sections include the following:

- Based on the image on the Shroud, the human body that was wrapped within the Shroud was a dead crucified man.
- In an apparently unique event, this dead body emitted a burst of radiation that burned an image of itself onto the linen burial cloth in which it was wrapped.

If we look through all of mankind's historical records, what man who died by crucifixion could have gone through a unique event in which his dead body emitted such a powerful burst of radiation that it burned an image of itself onto the linen cloth in which it was wrapped? In all our historical records, only one man and one event are suggested that fulfill these criteria. That one man is Jesus, and the one event is his reported disappearance from within his burial shroud. It is concluded that it is most reasonable to believe that the Shroud of Turin is the authentic burial cloth of Jesus. There does not seem to be any reasonable alternative.

Once it is recognized that the Shroud is the authentic burial cloth of Jesus, it becomes easy to answer many other questions such as:

- Why is there pollen unique to Jerusalem on the Shroud?
- Why is there pollen from a plant with long thorns around the image of his head?
- Why is there bilirubin and nanoparticles of creatinine and ferritin in the blood, both of which indicate that the man had been tortured prior to his death?
- Why are there microscopic chips of a type of limestone on the Shroud that is primarily located in Jerusalem?
- Why is there a microscopic amount of dirt in abrasions on the nose and one knee?
- Why do the wounds show that the nails were placed in the wrists and the thumbs folded under, contrary to paintings from the Middle Ages?

- Why is there blood running down his arms at the correct angles for crucifixion?
- Why are there puncture wounds on his scalp?
- Why are there abrasions across his shoulders?
- Why are there 100 to 120 blood marks across his body as though from a flogging, with serum rings around the blood marks, when the serum rings are only visible under ultraviolet light?
- Why is there a narrow elliptical hole in the man's side just the size of a Roman thrusting spear?

6. What Caused the Radiation to be Emitted?

In following the evidence where it leads, it has been concluded that a burst of radiation was evidently emitted from within a dead body that produced a good resolution image of itself on the linen cloth in which it was wrapped. But with this conclusion comes a new mystery. How was such a burst of radiation emitted from within a dead body? This event should be recognized as beyond or outside of our current understanding of the laws of physics. As a result, our current understanding of the laws of physics should not be expected to explain the event. Further scientific understanding of how the radiation was emitted will probably come, if at all, only from further evidence obtained from the Shroud, since it is our only source of scientific information regarding this event. The same applies to characteristics of the radiation, such as the conclusion that the radiation was evidently vertically collimated, both up and down. The conclusion in the previous section that the Shroud of Turin is the authentic burial cloth of Jesus raises a possibility. The reported disappearance of Jesus' body from within the Shroud (John 20:2-9) is also an event that is beyond or outside of our current understanding of the laws of physics. Perhaps the radiation was emitted from within the dead body when the body disappeared from within the Shroud, since both appear to be unique events that are outside of our current understanding of science. The question of how the body disappeared is discussed further in Ref. 24 and 25.

7. Conclusion

The goal of this study has been to determine whether the Shroud of Turin could be the authentic burial cloth of Jesus. The method of this study has been forensic science – to follow the evidence where it leads without being restricted by a presupposition of naturalism. The image on the Shroud is that of a man that was crucified exactly as the New Testament describes that Jesus was crucified. The discoloration mechanism that formed the image required two things – energy to drive it and information to control it. Information is required to control the discoloration mechanism so that only specific fibers and only specific lengths of those fibers are discolored so that the image could be formed. The required information is that which defines the appearance of a naked crucified man. We can see the image on the Shroud because this information is encoded into the pattern of discolored fibers that forms the image. The information that defines the appearance of a crucified man could only have come from the body. All methods for transporting this required information from the body to the cloth can be rejected for the Shroud except for radiation. Only radiation, by its energy, intensity, and direction, would have been capable of communicating this information from the body to the cloth that is required to form a good resolution image on the Shroud. To discolor only the top one or two layers of fibers in a

thread, the radiation must have been emitted in an extremely intense and extremely brief burst. Thus, it is most reasonable to believe that a burst of radiation was emitted from within the body that carried the required information from the body to the cloth to control the mechanism that formed the image. This radiation was probably vertically collimated – both vertically up and vertically down, to produce such good resolution front and back images without side images. Based on experiments to date, the radiation that formed the images might have included ultraviolet light and/or particles such as protons. This radiation might have caused a type of static discharge called a corona discharge to be released from the tips of the fibers, which caused them to discolor. The fibers that form the image would not have been discolored by gammas or X-rays or neutrons because they are too penetrating. However, if neutrons were included in this burst of radiation emitted from within the body, it would explain the carbon dating of the Shroud to 1260 – 1390 AD. A small fraction of these neutrons would have been absorbed in the trace amount of N^{14} in the Shroud to create new C^{14} in the Shroud, which would shift the carbon date forward. For example, to shift the carbon date for the sample location forward from 33 to 1260 AD requires only a 16% increase in C^{14} content. This neutron absorption hypothesis is the only concept that explains all four things that are known about carbon dating as it relates to the Shroud – the date, slope, and range of the measurement data at the sample location, and the C^{14} date for the Sudarium of Oviedo. The best explanation for a dead crucified body emitting a burst of radiation that formed an image of itself on linen is that this was Jesus' body, and the event was the reported disappearance of his body from within the Shroud. Thus, based on the preponderance of the evidence, it is most reasonable to believe that the Shroud of Turin is the authentic burial cloth of Jesus. This conclusion is corroborated by the historical research discussed in the introduction.

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Biography

Robert A. Rucker earned an MS degree in nuclear engineering from the University of Michigan and worked in the nuclear industry for 38 years primarily in nuclear reactor design, nuclear criticality safety, and statistical analysis for quality control of nuclear material inventories. He holds two Professional Engineering (PE) certificates in nuclear engineering and in mechanical engineering. He organized the International Conference on the Shroud of Turin (ICST-2017) held July 19-22, 2017, in Pasco, Washington. His papers can be downloaded from the RESEARCH page of his website www.shroudresearch.net. Send comments, questions, or corrections to robertarucker@yahoo.com.

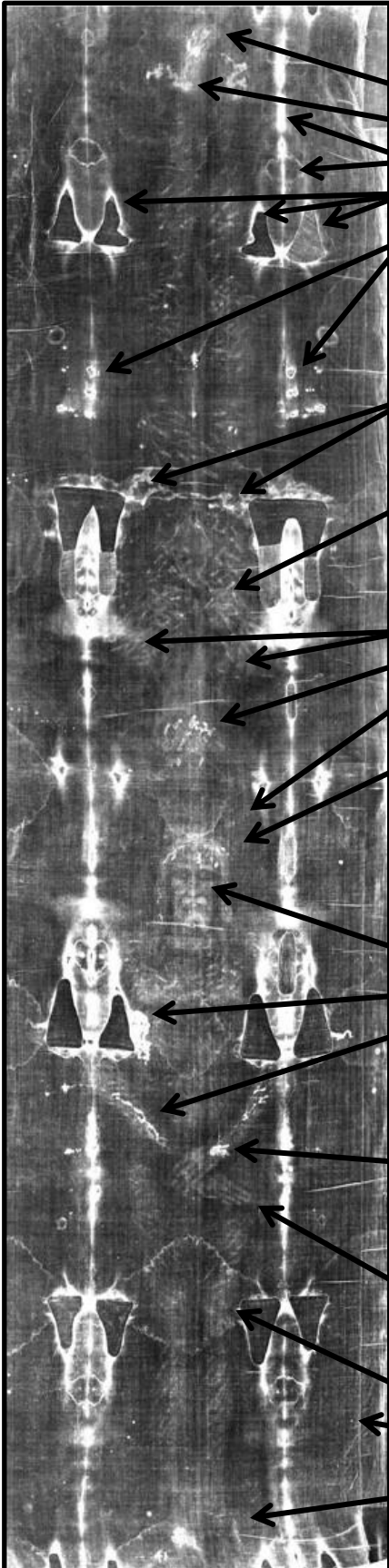


Figure 1. Front and Back Images on the Shroud of Turin

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.