

Role of Radiation in Image Formation on the Shroud of Turin

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Abstract

Formation of the image on the Shroud required three things: a discoloration mechanism, energy, and information. There must have been some process or mechanism that caused discoloration on the top portions of the fibers that make up the image on the cloth. Energy would have been required for the functioning of the discoloration mechanism to alter the electron bonds of the carbon atoms in the cellulose molecules that caused the discoloration. And information defining the shape of the body and the presence of some of the bones was needed to guide the process so front and dorsal images with good resolution could be formed. It is argued that if we follow the evidence where it leads and not be constrained by a presupposition of naturalism, then we find the best explanation for the evidence is that the required energy was delivered to the Shroud by radiation emitted from within the body, and this radiation must have been vertically collimated both up and down. Seventeen reasons are given for this view. The radiation emitted from within the body, by means of its intensity and direction, carried the necessary information from the body to the cloth so the image could be formed. A working hypothesis is developed for this emission of radiation from within the body in terms of when, where, what, why, and how. Responses are given to multiple questions that arise regarding this working hypothesis. And lastly a two-step image formation mechanism is proposed based on radiation emitted from within the body, which caused a static discharge on the top portion of the fibers, which caused the discoloration of the fibers making up the images.

1. Introduction

The Shroud of Turin, also commonly called the Turin Shroud, is a burial cloth that has been in Turin, Italy, since 1578. The amazing thing about this burial cloth is that it contains full size good resolution images of the front and back of a naked man that was crucified exactly as the New Testament says Jesus of Nazareth was crucified. When put on display, which usually occurs several times each century, millions of people file past it and see the images of the crucified man. Long standing tradition maintains the Shroud of Turin is the authentic burial cloth of Jesus. Ancient documentation and a variety of ancient coins and artistic works are consistent with this view.

The scientific investigation of the Shroud of Turin began in 1898 when Secondo Pia took the first photograph of it. This photo revealed the image on the cloth was a good resolution negative image. This contradicted the generally held opinion that the image on the Shroud was a painting, because no artist of a previous era could paint a negative image, because he would have never seen a negative image. It has now been scientifically studied since 1898 making it the most studied ancient artifact in existence. This scientific research has shown the characteristics of the image to be so unique that it could not be the result of a human agent, either an artist or forger, because the technology to create this image did not exist in a previous era and still does not exist even today. Based on this scientific research, the general consensus of Shroud

researchers is that it wrapped a real human body that was crucified, and that in some way this body encoded front and dorsal images of itself onto the cloth in which it was wrapped.

2. Methodology

Much of the time and effort spent on this scientific research has assumed the cause of the image must be in accordance with the laws of science as understood at the time. This is done through a philosophical presupposition of naturalism – that only the laws of science as we currently understand them can be used to explain the presence of the images on the Shroud. But this approach over this long period of time has not arrived at an acceptable explanation for the image, the date, and the blood. In fact, there are several good reasons to believe the processes or mechanisms by which the images were formed may not be within our current understanding of the laws of science:

- Scientific research on the Shroud since 1898 have not produced a naturalistic explanation that is consistent with both the macroscopic and microscopic characteristics of the image on the Shroud.
- Many individuals have attempted to reproduce the images using a variety of naturalistic processes but all attempts have failed to reproduce one or more of the image characteristics.
- Many researchers have concluded that the characteristics of the front and dorsal images on the Shroud are so unique they must have been encoded onto the cloth by radiation emitted from the dead body as it was wrapped in the cloth¹. Under normal conditions, the quantity and characteristics of the radiation that could be emitted from a dead body by the decay of naturally occurring isotopes could not form such an image, and never have. Thus, the process or mechanism by which the dead body within the Shroud emitted the radiation required to form the images must be outside of our current understanding of science.
- Anyone that looks through his clothing will find his body has not encoded good resolution front and dorsal images of itself onto the inside surface of any of his clothing. This certainly suggests the body of a living person cannot encode an image of itself onto a piece of cloth. Our current understanding of the laws of science does not include any mechanism for this to happen. Of the billions of people in all human history that have died, none of their dead bodies (except the body wrapped within the Shroud) have encoded an image of itself onto cloth. Thus, the above conclusion can be broadened to say there appears to be no mechanism in our current understanding of the laws of science by which the body of any one, whether living or dead, can encode its image onto a piece of cloth. The images on the Shroud of Turin are a totally unique phenomenon. If the images were encoded by a naturalistic process, then it is reasonable to expect there would be other examples of such images on cloth.
- Given the nature of the image – that of a man who was crucified exactly as the New Testament says Jesus was crucified, we need to consider the possibility it is the authentic burial cloth of Jesus and as such is the result of his death, burial, and possibly even his

1. Chapter 5 of “Test the Shroud” by Mark Antonacci, 2015, LE Press LLC, ISBN# 978-0-9964300-1-2

resurrection. The relevant passages in the New Testament are Matthew 27:27 to 28:20, Mark 15:16 to 16:8, Luke 23:26 to 24:53, and John 19:17 to 21:25. Mark 16:9 to 20 is omitted from the above list because it is probably of lesser historical reliability, because it is probably not authentic to the original manuscript of Mark. The point of this consideration is that Jesus' followers were convinced Jesus had disappeared from within his burial shroud as it lay in the tomb. If this disappearance of Jesus' body was an actual historical event, then it would be beyond or outside of our current understanding of science. And if the images were encoded onto the cloth at the time of the disappearance of the body from within the Shroud, then it would be reasonable to expect the mechanism by which the images were encoded is also beyond or outside of our current understanding of science.

- Ray Rogers in a paper² from 2005 claimed in his abstract that formation of the image on the Shroud of Turin “could not have involved energetic radiation of any kind; photons, electrons, protons, alpha particles, and/or neutrons.” Review of Rogers' paper³ found this conclusion is not justified by the evidence he presented, and in fact, the certainty of this conclusion contradicts the tentativeness of his last sentence in the body of the paper which says “I believe that the current evidence suggests that all radiation-based hypotheses for image formation will ultimately be rejected.” (Underlining added)

The above considerations point to the need to think “outside the box” created by the constraints of naturalism. Therefore, this approach will be utilized in this paper in an attempt to solve the mysteries of the Shroud. The ground rule for this approach is to follow the evidence where it leads, free from the constraints caused by a presupposition of naturalism. This approach recognizes that encoding of the front and dorsal images onto the Shroud probably involved new phenomena that are not within our current understanding of the laws of science. And since truth ought to be the goal of science, we must be willing to follow the evidence where it leads, even to the point of questioning our own basic assumptions.

In “following the evidence where it leads”, we are essentially attempting to “reverse engineer” the image formation mechanism, i.e. to determine how the image was encoded onto the Shroud based on the characteristics of the image. This approach can also be called “solving the inverse problem”. This is the process used in forensic science, in contrast to experimental science. In forensic science, it is not required or expected to reproduce the original cause in the laboratory. For example, a detective investigating a murder scene is not required to reproduce the original murder again and again in the laboratory, but he can still scientifically investigate various features of the case to determine how the murder was most likely committed and possibly the characteristics of the person who committed the murder. Similarly, if the original event involved the disappearance of Jesus' body from within his burial shroud, as historical sources such as John 20:1-10 indicate, then we would not expect to be able to reproduce the original event in the laboratory. But using forensic science we can still scientifically investigate the image and other features of the Shroud to try to determine the most likely way in which the image was formed.

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2. Raymond N. Rogers, “The Shroud of Turin: Radiation Effects, Aging, and Image Formation” June, 2005, available at <http://www.shroud.com/pdfs/rogers8.pdf> .
 3. R. A. Rucker, G. Fanti, M. Antonacci, T. Fleming, and K. Propp, “Review of ‘The Shroud of Turin: Radiation Effects, Aging, and Image Formation’ by Ray Rogers”, October 11, 2016.

One caution in “following the evidence where it leads” is this evidence may not be sufficient to guide us to answers for all our questions. For example, the detective in following the evidence at the murder scene may not be able to obtain answers to some of the important questions, but this failure should not negate what can be learned. So it is with our study of the Shroud. An inability to answer all the questions should not negate what can be learned, for we can only follow the evidence that is available.

When the progressive nature of our understanding of science is considered, this goal of “following the evidence where it leads” and thinking “outside the box” of naturalism should not be objected to as either unscientific or even startling. This is because it’s an essential axiom of science that scientists ought to be open to new phenomena and new information even if it conflicts with current scientific understanding so that our understanding of science can be modified and expanded to cover all events that have happened. It is potentially critical for us to understand how the image on the Shroud was formed because, depending on the nature of the results, it may be information that is necessary for humanity to form a correct view of reality. Everyone’s worldview may depend on it! Naturalism is discussed further in the response to question #1 on page 17.

3. Requirements for Image Formation

Formation of an image on any medium requires a mechanism to create shades or colors, energy to drive the mechanism, and information to control the mechanism so the correct amount of shading or color is placed at each location. Consistent with this, three basic things are required to encode the image of the body onto the Shroud: a mechanism to discolor the linen cloth, energy, and information:

1. A process or mechanism is needed to discolor fibers in the way the fibers are discolored on the Shroud:
 - The fibers on the Shroud are discolored with a straw-yellow or sepia color.
 - Of the approximately 200 fibers in a linen thread, only the upper portions of the top two or three layers of fibers in a thread are discolored.
 - Only the outer circumference of each fiber is discolored, with the inside of the fiber unaltered.
 - The thickness of the discoloration on a fiber is less than 0.4 microns, i.e. less than the wavelength of light.
 - The discoloration on the fibers is not due to pigment added to the Shroud but is due to a change from single to double electron bonds of some of the carbon atoms already in the cellulose molecule. This is essentially the same as the oxidation-dehydration process that results from aging of cloth. The amazing thing is this process produced the image of a crucified man on the Shroud.
 - There may be a very slight amount of discoloration on the reverse side of the Shroud that could indicate a possible image of the face and the hands was formed on the outside of the wrapped configuration.

Based on its location and nature, this discoloration of the fibers that make the image is probably caused by a static discharge from the top portions of the fibers⁴ – essentially a “lightning rod” effect. This static discharge is associated with a significant electrical current through the top portions of the fibers. This caused heating of the thin outer region of the fibers, which caused the change in the electron bonding of the carbon atoms in the cellulose molecule.

2. There must also be a source of energy to drive the image encoding mechanism, whether it is caused by a static discharge or some other process. The proposed source of this energy to drive the image encoding mechanism is radiation possibly in the form of low energy charged particles and/or electromagnetic radiation. Examples of charged particles include protons or electrons, though there are many other types of charged particles in the standard model of particle physics. Examples of electromagnetic radiation include infrared, visible, and ultraviolet (UV) light. For electromagnetic radiation, the smallest packet of energy is called a photon. The image was not caused by highly penetrating radiation, such as neutrons, X-rays, or gamma rays because if it were, then fibers would be discolored across the entire thickness of the threads and an easily visible image would have been formed on the reverse side of the Shroud, i.e. on the outside of the wrapped configuration, which is contrary to the evidence on the Shroud. Particles that are electrically charged such as protons (+1) and electrons (-1) are not very penetrating because their electrical charge interacts with the cloud of electrons surrounding the nucleus of each atom, so these particles, at a low enough energy, are good candidates to provide the energy to drive the image encoding mechanism. On the other hand, neutrons are very penetrating because they are electrically neutral so do not interact with the cloud of electrons around the nucleus of each atom but only interact if they hit the much smaller nucleus at the center of each atom. There is experimental evidence that protons⁵ and an extremely brief pulse of infrared⁶ or ultraviolet light⁷ can cause discoloration like on the Shroud. There is no good basis to exclude any of these options.

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4. Robert A. Rucker, “Holistic Solution to the Mysteries of the Shroud of Turin”, July 16, 2020, “Why we Can See the Image on the Shroud”, June 29, 2020, “How the Image Was Formed on the Shroud”, June 29, 2020, “Image Formation on the Shroud of Turin”, July 14, 2019.
 5. Jean-Baptiste Rinaudo, “Modello protonico di formazione dell'immagine sulla Sindone di Torino” (Protonic Model of Image Formation on the Shroud of Turin) presented June 6, 1998, in Torino, Italy, at the *III Congresso Internazionale Di Studi Sulla Sindone (3rd International Congress of Studies on the Shroud)*. The web site for the 1988 conference in Turin (<http://www.shroud.com/turinsym.html>) lists this presentation under the chemistry sessions in room 200 on Saturday June 6, 1998, though no paper is available from this web site. Mark Antonacci received a draft document in English at the conference. Also see Mark Antonacci, “Particle Radiation from the Body Could Explain the Shroud’s Images and its Carbon Dating” accepted 12 July, 2012, *Scientific Research and Essays* Vol. 7(29), pp. 2613-2623, 30 July, 2012, Available online at <http://www.academicjournals.org/SRE>, DOI: 10.5897/SRE12.376, ISSN 1992-2248 ©2012 Academic Journals. Also see Chapter 10 of *The Resurrection of the Shroud, New Scientific, Medical and Archeological Evidence*, 2000, and Chapter 5 of *Test the Shroud*, 2015, both books by Mark Antonacci
 6. C. Donnet, J. Granier, G. Verge, Y. Bleu, S. Reynaud, and F. Vocanson, “2D Reproduction of the Face on the Turin Shroud by Infrared Femtosecond Pulse Laser Processing”, *Applied Optics*, March 20, 2019
 7. Paolo Di Lazzaro, et al., “Shroud-like Coloration of Linen by Nanosecond Laser Pulses in the Vacuum Ultraviolet”, 2012, “Superficial and Shroud-like Coloration of Linen by Short Laser Pulses in the Vacuum Ultraviolet”, January, 2013, “A Ray of Light on the Shroud of Turin” published in the Proceedings of the Conference “FIAT LUX – Let there be light” held in Rome, Italy, on 3-5 June 2015. The summary on page

3. Information must also be provided to the image encoding mechanism in a way that guides or controls it to produce the image of the crucified man. For example, the discoloration mechanism must be able to discolor certain fibers but not discolor other fibers next to them based on this information. And the discoloration mechanism must be controlled to discolor the correct length of each fiber based on this information. This means the information that controlled the image encoding mechanism must have defined the appearance of the crucified man that was wrapped in the Shroud. This information does not need to define the color of the body for the color of the body is not indicated on the Shroud. This information needs to define only the shape of the body in terms of the vertical distance between the body and the cloth, for researchers have concluded that is what the shades of discoloration on the Shroud indicate. This is how the 3D or topographic effect is created in the image. This information could not have come from the limestone of the tomb, or from the air in the tomb, for this information was not inherent to these materials. It could only have come from the actual vertical distance between the body and the cloth. Thus, this information in some way must have been transported from the body to the cloth across the air gap between the two. The only option to transport, or communicate, this information to the cloth is by radiation that passes through the air gap and is thus altered by it. The other options for communicating information from one location to another (waves in a medium, flow of particles in physical connections such as wires, direct contact, and diffusion of molecules) must be rejected for the Shroud⁸. Thus, the radiation that delivered the energy necessary for the discoloration mechanism to function (#2 above) also communicated to the cloth the information that specified at every point the body-to-cloth vertical distance required to produce the 3D information on the Shroud.

Radiation, by means of its frequency, intensity, and direction is ideally suited to communicate information. For example, in a visual image, it is electromagnetic radiation, i.e. reflected photons of light by their frequency, intensity, and direction, that transfer the information related to the color, shade, and location of points in the scene in front of us to our eyes so we can see our surroundings⁸. Radiation is also the most common means of communicating information in our surroundings and in our culture. The role of radiation in image formation on the Shroud should not be rejected because radiation sounds strange or weird, for each of us live with radiation continually all around us. It should be noted that the information deposited on the Shroud must also include information related to the presence of the bones near the surface of the body, since images of some of these bones (teeth, vertebrae, bones in the hands and skull) are present on the Shroud. This means the radiation that came from the body was not just emitted from the surface of the body but must have been emitted from within the body. This is the only way in which the radiation could have picked up the information content related to the presence of these bones and communicated it to the Shroud.

Thus, to encode the front and dorsal images onto the Shroud, the discoloration mechanism (#1 above) had to utilize the energy provided to it by the radiation that came from the body (#2 above) in a way that was controlled by the information (#3 above) carried on

8 is particularly helpful. Also, Louis C. de Figueiredo, “Dr. Paolo Di Lazzaro Explains His Research on Image Formation on the Shroud of Turin” and S. S. Spicer and E. T. Toton, “Electric Charge Separation as the Mechanism for Image Formation on the Shroud of Turin: A Natural Mechanism”, Nov. 29, 2014

8. Robert A. Rucker, “Information Content on the Shroud of Turin”, February 29, 2020

that radiation. This statement has very wide application. The discoloration mechanism referred to above could be a photo-chemical process, or a high temperature due to a static discharge, or some other process. The radiation that came from the body could be low energy charged particles and/or electromagnetic radiation. And, assuming the body disappeared from within the Shroud, the above statement is true whether or not the image was encoded onto the Shroud as the result of the cloth collapsing into the volume previously occupied by the body, which is a common hypothesis for image formation.

4. Evidence for Radiation

Following the evidence where it leads while rejecting the constraints of naturalism, the evidence indicates it to be highly probable that the image was formed by radiation emitted from within the body as it was wrapped within the Shroud. Seventeen reasons for this are given below:

1. Science has disproven all other suggested possibilities for the cause of the image.
 - The image is not caused by paint or stain, since there is no evidence of pigments, carrier, or brush strokes in the image. Also, nothing is binding the discolored fibers or threads together and the image shows no sign of cracking or chipping due to centuries of folding and rolling. And if the Shroud were the result of an artist, then the artistic technique used to create the image is unique to the Shroud and the artist is totally unknown. The image on the Shroud also has no outline, contrary to common artistic technique.
 - The Shroud was in a fire in 1532 which scorched portions of it and would have produced a temperature gradient across it. However, this temperature gradient did not cause any change in the intensity of the fiber discoloration in the image. This indicates the image is not due to the application of an organic chemical.
 - Microscopic examination of the image found no evidence of capillarity (soaking up of a liquid) of the discoloration, either in the fibers or the threads. This indicates the image is not due to application of a liquid such as an acid, or any organic or inorganic chemical in liquid form. This would include paint, dye, or stain.
 - The front and dorsal images of the crucified man can be seen in front lighting but cannot be seen in rear lighting. This indicates the image is not due to the application of any substance (matter, atoms) to the front surface of the cloth. This means the image is not a rubbing, a dusting, or a print.
 - Paintings and photographs do not contain 3D information, but the image on the Shroud does. Thus, the image is not a painting or a photograph. Also, no chemicals sensitive to light were found on the cloth, which confirms the image could not be the result of a photographic process.
 - No other chemicals were found on the Shroud. For example, no chemicals that might commonly be used in the burial process in the first century (myrrh or aloes, John 19:39) were found. The normal products of body decay were also not found. This means the image is not due to a naturalistic process of chemicals placed onto the body reacting with chemicals produced by decay of the body.

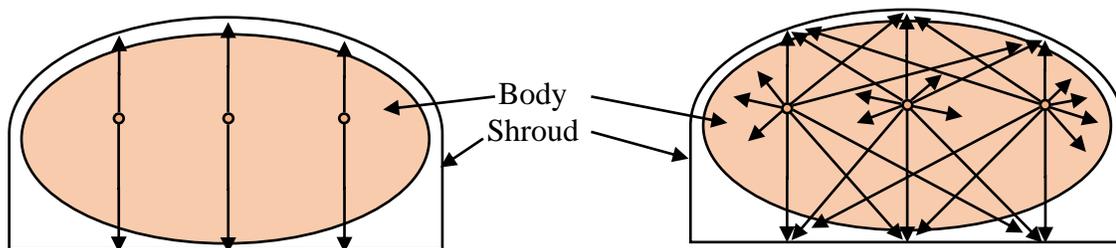
- The coloration of the image makes it appear to be a scorch. A scorch is typically due to contact of a hot object with cloth, like an iron on a cotton sheet. This type of scorch will fluoresce under ultraviolet light. When tested, the image did not fluoresce under ultraviolet light, so the image could not be a scorch produced by contact of a hot object with the Shroud.
2. The straw-yellow or sepia color of the image makes it appear to be a scorch, but the color is not caused by extended contact between the cloth and a hot object because the image does not fluoresce, as discussed above. But a very light scorch does not fluoresce. A very light scorch could conceivably be the result of a very brief contact with an elevated temperature or the result of an extended contact with a temperature that is not hot enough to cause a heavy scorch. Attempts to use these mechanisms to cause a very light scorch indicate that the light scorch penetrates through the entire thickness of the cloth⁹, whereas the discoloration of the Shroud image is only on the top two or three layers of fibers in a thread. Thus, the image discoloration is not due to these processes. Another possibility is that radiation absorbed by a material can cause a discoloration even if the material and the surroundings are not at an elevated temperature. This is sometimes called a “cold” scorch. Examples of this are the discoloration on a hanky left out in the sun for several days, and a sunburn on skin even when the air temperature is not elevated. Radiation can cause a scorch on cloth which does not fluoresce under UV light. Since the image does not fluoresce under UV light, this implies the image could have been caused by radiation absorbed by the cloth.
 3. If the image was caused by radiation, then the radiation had to come from somewhere. Most researchers believe the evidence requires that the Shroud wrapped a body of a crucified man. These researchers appear to agree that the front and dorsal images of the crucified man were created on the inside of the Shroud as it wrapped the body. This is clearly the case since the blood on the cloth had to come from the body and since the blood marks that did not soak through the cloth are on the same side as the image. Since the cloth above the body was discolored on the bottom of the cloth that faced the body, the radiation had to come from below the upper cloth. And since the cloth under the body was discolored on the top of the cloth that faced the body, the radiation had to come from above the lower cloth. This means the radiation had to come from the volume between the upper cloth and the lower cloth as it wrapped the body. But since that volume was occupied by the body, the radiation had to come from the body.
 4. Based primarily on the nature of the blood on the Shroud, the first several decades of research led researchers to conclude the blood came from the body of a person who was crucified and then wrapped in the Shroud, so this dead body in some way must have caused the front and dorsal images on the Shroud. But for the dead body to cause the images, a unique process must have been involved. A human body forming a front and dorsal image of itself with good resolution on a piece of cloth is unique to the Shroud of Turin. There is no other example of such a thing happening in human history, whether the person was alive or dead. Because of the unique characteristics of this image, it is not possible for the image to have been formed by a human agent, either artist or forger, in a previous era or even

9. Thibault Heimburger, “The Scorch Hypothesis: New Experiments”, April 2014

today. In simple terms, the technology to produce the image has never existed. Scientific research on the Shroud since 1898 has not discovered a naturalistic explanation. The uniqueness of the image is consistent with it being due to a unique event, such as radiation being emitted from within the body that was wrapped within the Shroud.

5. Our brains recognize the image to be a crucified man because the pattern of discolored fibers on the Shroud contains the information that defines the appearance of a crucified man, specifically in terms of the vertical distance between the body and the cloth. This information could have only originated from the vertical distance between the body and the cloth at every point on the body as it was wrapped in the Shroud. This information could not have come from the limestone of the tomb, the air in the tomb, or from the manufacturing process of the cloth. This information must have been produced by something that flowed from the body to the cloth that diminished as it passed through the air gap between the body and the cloth. The only option to communicate this information is radiation, as discussed above in #3 on page 5. Such radiation could be diminished by absorption or scattering by the air in the gap, or by decay of particle radiation.
6. Researchers report the images show bones that were close to the surface of the body (teeth, vertebrae, and bones in the hands and skull). This indicates something flowed from the body to the cloth that picked up the information related to the presence and configuration of the bones near the surface of the body, and carried that information to the cloth where it was deposited. Since radiation is the only option for communicating such information to the cloth⁸, the most reasonable explanation is that radiation was emitted from within the body. This information regarding the bones could have been communicated to the Shroud either by radiation emitted behind the bones being altered in intensity as it passed vertically through the bones, or by the bones vertically emitting more radiation than the surrounding material.
7. The front and dorsal images on the Shroud have good resolution, with the resolution estimated to be about 5 mm or less. There are no images of the side of the body or the top of the head. To encode good resolution images onto the Shroud, there must have been a one-to-one correspondence between each point on the surface of the body and each point on the cloth, so that each point on the surface of the body affects only one point on the Shroud and each point on the Shroud is affected by only one point on the surface of the body. Since there were no lenses between the body and the cloth to focus the radiation, and assuming the body and the cloth were not in a strong enough electric field to control the movement of charged particles, the best explanation for how this could have been accomplished is that radiation was emitted within the body, with this radiation emitted in a vertical direction – vertically up and vertically down. This is shown in the left figure below. And with the radiation only emitted in vertically up and vertically down directions, no image of the side of the body or the top of the head would be formed, consistent with the evidence on the Shroud.

As shown in the right figure below, if radiation is emitted randomly in all directions from every point in the body, then each point on the cloth would receive radiation, and hence the information carried by that radiation, from many points in the body, leading to confusion of the information, leading to no image on the cloth.



Vertical emission maintains the one-to-one correspondence, resulting in good resolution.

Random emission does not maintain the one-to-one correspondence, resulting in no resolution.

Consider how our eyes function. When we view the scene in front of us, our eyes can produce a high-resolution image of the scene on the retina at the back of the eye because each eye contains a lens. Even though photons are being reflected in all different directions from every point in the scene in front of us, so that photons are entering our eyes from many different points in the scene in front of us, the presence of the lens in each eye is able to focus those photons onto the retina so that a high resolution image can be formed. If there were no lens in the eye, no image of the scene in front of us could be formed on the retina. Similarly, for the Shroud, since there was no lens between the body and the cloth, no image of the body could be formed on the cloth if radiation were released in random directions from every point within the body. But a good resolution image can be produced if the radiation emitted from every point in the body was initially released in a vertical direction, collimated vertically up and vertically down, assuming the body was lying horizontally in the tomb. It should be pointed out that even if the radiation were initially emitted in perfectly vertical directions, some degree of scattering of the radiation would be expected as the radiation passed through the body, through the air in the body-to-cloth gap, and through the cloth. Such scattering would decrease the resolution of the image formed on the Shroud. This may be the explanation why the very dim image of a face that some claim is on the reverse side of the cloth, that faced away from the body in the wrapped configuration, appears to have a lower resolution than the image of the face on the inside of the cloth, that faced toward the body. As the radiation penetrated through the cloth from the inside surface to the outside surface of the cloth, it would have gone through additional scattering events which would have reduced the resolution of the image produced on the outside of the cloth.

8. Only the top two or three layers of fibers in a thread are discolored, The depth of the discoloration is less than 0.4 microns – less than a wavelength of light, and this thickness of discoloration is circumferential around the outside of the fiber. The most likely cause of this type of discoloration was probably a static discharge from the top fibers that were facing the body– essentially a “lightning rod” effect, which caused a flow of electrons and the resultant heating in the thin surface region of the fibers thus explaining the location and the thinness of the discoloration. This needs an energy source such as radiation. Charge particles is the primary candidate to cause such a static discharge.

9. The image is a negative (reverse) image that contains 3D or topographic information content related to the distance of the cloth from the body. The 3D effect is due to the intensity of the image being approximately inversely proportional to the vertical distance of the cloth from the body, with no image formed when the cloth was more than about 3 or 4 cm from the body. This can be explained by radiation that went from the body to the cloth, with its intensity decreasing as it passed through the air gap between the body and the cloth due to absorption, scattering, and/or decay, until it was not strong enough to cause any discoloration. This implies the discoloration mechanism has a threshold energy, i.e. at least a certain amount of energy must be applied to the discoloration mechanism or it will not cause discoloration at all. An example of a threshold energy level is the ionization potential in the photoelectric effect, where the photon must have at least a certain amount of energy to knock an electron out of its orbit. Examples of threshold mechanisms that could have caused discoloration on the Shroud include a photo-chemical process as suggested by Di Lazzaro⁷ or a static discharge as discussed in this paper.
10. Microscopic analysis of the Shroud shows that discolored threads/fibers prevent threads/fibers below them from being discolored. This “shadow” on the lower threads or fibers indicates something probably flowed from the body to the cloth, and that this flow was essentially vertical. If the discoloration is due to a static discharge from the fibers, then the static discharge would take place from the highest portions of the threads/fibers closest to the body and not from the underlying threads/fibers, thus creating the “shadow” effect. But this process would be the result of radiation from the body hitting the cloth.
11. The front and dorsal images have nearly the same intensity in spite of the fact that the front of the body only had the weight of the cloth on it whereas the back of the body had the entire weight of the body on it. If for example, the discoloration on the cloth were proportional to the degree of contact between the body and the cloth, then the back or dorsal image should be significantly darker than the front image. But if the image formation was due to radiation emitted from within the body, and it was emitted vertically up and vertically down, then both images should be equally dark.
12. The discoloration on the fibers is not due to any pigment but is due to some of the carbon atoms in the cellulose molecule having their bonds to the surrounding atoms altered from single to double electron bonds. The electron bonds of carbon in the cellulose molecule could only have been altered by time, chemical interaction, or radiation. But time could not create the image of a crucified man. The discolored sections of the fibers show no evidence of capillarity (soaking up of a liquid), so the discoloration cannot be due to a chemical reaction involving a liquid such as acid or an organic or inorganic chemical in liquid form. Thus, the only remaining possible cause is radiation.
13. The image consists of altered electron bonds of carbon in the cellulose molecule. Energy must have been deposited on the Shroud to cause this alteration in the electron bonds. In 1978, STURP discovered the image is not visible in back lighting. From this, they concluded the image was not caused by any substance (matter, atoms) deposited onto the Shroud. The transfer of energy without the transfer of substance (matter, atoms) is only accomplished by radiation.

14. Experiments have shown fiber discoloration like that on the Shroud can be caused by protons⁵ or an extremely brief pulse of infrared⁶ or ultraviolet light⁷. Both options are consistent with the hypothesis that radiation was emitted from within the body wrapped within the Shroud. At this point in the scientific investigation, neither option can be disproven, and the burst of radiation may have been a combination of multiple types of radiation.

15. Neutrons emitted from within the body can explain the four mysteries related to the carbon dating¹⁰ :
 - In 1988, the Shroud was carbon dated to 1260 ± 31 AD (uncorrected), which translates to a two sigma (95% probability) range of 1260 to 1390 AD when corrected for the changing C¹⁴ production in the upper atmosphere. If the image was formed by radiation emitted from the body, and neutrons were included in this radiation, then a small fraction of these neutrons would have been absorbed in the trace amount of N¹⁴ that was naturally in the linen fabric to form new C¹⁴ atoms in the Shroud by the [N¹⁴ + neutron → C¹⁴ + proton] reaction. This new C¹⁴ would have shifted the carbon date in the positive direction because it would have been indistinguishable from the C¹⁴ brought into the flax plant while it was alive. Nuclear analysis computer calculations indicate if 2.0×10^{18} neutrons were released from within the body, then the amount of C¹⁴ on the 1988 samples would have been increased by 16%, which would have shifted the carbon date from about 33 AD to 1260 AD. Of course the three dating laboratories and those who performed the statistical analysis of the experimental results¹¹, not suspecting the cloth had experienced an event in which it had absorbed neutrons, simply reported the average value for the carbon date (1260 ± 31 AD, uncorrected).

 - The average carbon dates reported by the three laboratories did not agree well with each other. When these average values from the three laboratories are plotted as a function of the distance of the sample from the bottom end of the Shroud, a slope or gradient in the data of about 36 years per cm (91 years per inch) is apparent¹². If neutrons were homogeneously (uniformly) emitted from within the body, then the natural shape of the neutron distribution in the tomb will cause the slope of the carbon date experimentally determined by the dating laboratories. This shape of the neutron distribution in the tomb was calculated by the MCNP (Monte Carlo n-Particle) nuclear analysis computer code.

 - Statistical analysis of the values obtained in the 1988 carbon dating of the Shroud indicates the spread or variation of the values have only about a 1.4% chance¹³ of being within the variation allowed by the measurement uncertainties. This is less than the usual 5% acceptance criterion, which indicates an unexpected factor likely altered the

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10. Robert A. Rucker, “The Carbon Dating Problem for the Shroud of Turin, Part 3: The Neutron Absorption Hypothesis”, July 7, 2018
 11. P. E. Damon, et al. (21 authors), “Radiocarbon Dating of the Shroud of Turin” by Nature, Vol. 337, No. 6208, pages 611-615, February 16, 1989. This paper is often called Damon.
 12. Figure 3 in “The Carbon Dating Problem for the Shroud of Turin, Part 2: Statistical Analysis” by Robert A. Rucker, August 7, 2018
 13. Bottom value for material 1 in Table 6 in “The Carbon Dating Problem for the Shroud of Turin, Part 2: Statistical Analysis” by Robert A. Rucker, August 7, 2018

samples, resulting in a systematic error in the measured dates, which caused the measured values to be heterogeneous, i.e. essentially different from each other. The heterogeneity of the measured values has been proven by detailed statistical analysis of the measurements¹⁴. Such a systematic error in the measured values would have been produced by the production of new C¹⁴ on the Shroud by neutron absorption in the N¹⁴ in the cloth¹⁵.

- The Sudarium of Oviedo, which ancient tradition and historical documents probably indicates is the face cloth of Jesus, was carbon dated to about 700 AD. If 2.0×10^{18} neutrons are released from within the body, and if Jesus' face cloth, after being removed from Jesus' face, was placed on the right shelf in the tomb just in front of the back shelf, then enough new C¹⁴ would have been produced in the face cloth to shift the date from about 33 AD to 700 AD¹⁶.

The only proposed hypothesis able to explain the above mysteries related to carbon dating is neutrons emitted from within the body as it was wrapped within the Shroud. The invisible reweave hypothesis was conceived to explain the first mystery (the carbon date of 1260 date). For the invisible reweave hypothesis to explain the second mystery (the slope of about 40 years/cm), a second assumption must be made regarding the fraction of the old cloth that was replaced with new cloth as a function of the distance from the end of the cloth. The invisible reweave hypothesis is not consistent with no subsamples dating to about 33 AD or why the Sudarium of Oviedo was carbon dated to 700 AD.

16. The color of dried blood is dark brown or black, but the blood on the Shroud has a reddish hue. Why is this? Experiments have shown dried blood can retain a reddish color if it has been exposed to neutrons, followed by ultraviolet light as in sunlight¹⁷. There may be other explanations for the reddish hue of the dried blood, but neutron absorption in the blood appears to be a possible explanation.
17. When the body of the crucified man was wrapped with the Shroud, the body would have had some holes in the skin through which blood could have continued to drain for some time, such as the feet and the side wound. But most of the blood would have dried on the body, such as from the scourge marks and the blood that ran down his arms and forehead. Dried blood will not soak into cloth, and in fact requires some effort to wash off of the skin. The mystery is how this dried blood was moved from the body to the cloth, even where the two would not have been in contact. This transfer must have happened while the body was wrapped inside the Shroud. The hypothesis of radiation emitted from within the body includes a possible explanation for this mystery. Radiation carries momentum so, by a transfer of momentum, it can exert force on an object. The term for this is "radiation

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14. T. Casabianca, E. Marinelli, G. Pernagallo, and B. Torrissi, "Radiocarbon Dating of the Turin Shroud: New Evidence from Raw Data", (2019), *Archaeometry*, 61(5), 1223-1231; Bryan Walsh and Larry Schwalbe, "An Instructive Inter-Laboratory Comparison: The 1988 Radiocarbon Dating of the Shroud of Turin", *Journal of Archaeological Science: Reports*, Volume 29, February 2020;
 15. Robert A. Rucker, "Carbon Dating of the Shroud is Explained by Neutron Absorption", July 16, 2020.
 16. Figures 12 and 13 in "The Carbon Dating Problem for the Shroud of Turin, Part 3: The Neutron Absorption Hypothesis" by Robert A. Rucker, July 7, 2018.
 17. Carlo Goldoni, "The Shroud of Turin and the bilirubin blood stains", International Conference on The Shroud of Turin: Perspectives on a Multifaceted Enigma", Columbus, Ohio, August 14-17, 2008

pressure”. If a burst of vertically collimated radiation emitted within the body were sufficiently brief and intense, it would lift the blood off the body, accelerate it vertically away from the body, and thrust it onto and into the Shroud.

The blood appears to have been transferred to the Shroud in a liquid state, apparently as normal blood, which then dried on the fabric. This is because of its normal and pristine appearance in the way it dried on the cloth, including smooth undistorted edges, the shape of the solidified blood components, and the presence of blood serum halo rings around these solidified components. These serum halo rings are only visible under ultraviolet light, and appear to indicate the blood had to be in a liquid state on the Shroud so that the liquid blood serum could spread beyond the dried blood components by capillary action (tendency to soak up liquids) in the linen. How could the blood initially be in a liquid state on the Shroud when the blood marks, except possibly those with underlying wounds, would have dried on the body? Would the process of the radiation pressure thrusting the blood off the body and onto the cloth liquify the dried blood? This does not seem possible. The other option is the blood was liquified prior to it being thrust off the body, as if it had returned to a living state! What could have caused this? Thus, the blood may be the most significant mystery related to the Shroud.

5. Working Hypothesis for Radiation Emission

If we choose to not be restricted by the constraints of naturalism, but instead choose to follow the evidence on the Shroud where it leads, then we find there are multiple evidences (as discussed in the previous section) which indicate radiation was probably released from the dead body as it was wrapped in the Shroud. But there are many questions related to the possibility of radiation being emitted from the body that are difficult to answer definitively because we have no experimental data for what kind of radiation could or would be emitted in such a unique event. In spite of this difficulty, the many evidences for radiation being emitted from the body motivate us to develop the most reasonable working hypothesis for radiation emission from the body. Such a working hypothesis should be useful to suggest experiments that could be performed to test the hypothesis. The following is this working hypothesis:

When: The best explanation for the evidence on the Shroud is that radiation was released by the dead body as it was wrapped in the Shroud. As such, this event is outside of our current understanding of the laws of science. There are also historical reports, recorded in the gospels of the New Testament (John 20:1-10), that the body of Jesus disappeared from within the Shroud. If this was a real historical event and was accurately reported by the observers, then this event would also be outside of our current understanding of the laws of science. Under the assumption that the historical documents attest to a real historical event, it is most reasonable to associate these two unique phenomena together, so that the radiation was released from Jesus’ body in the process of his body disappearing from within the Shroud. This assumption implies the radiation was released only over the time during which the body was disappearing. But how long did it take for the body to disappear? To answer this question, evidence from both scripture and the Shroud needs to be considered. According to the Bible, the future resurrection of the righteous will occur “in the twinkling of an eye” (1 Cor. 15:52), and Jesus’ resurrection is the “first

fruits”, i.e. first occurrence, of the believer’s future resurrection¹⁸ (1 Cor. 15:20, 23). Thus, Jesus’ resurrection should have taken the same amount of time as the future resurrection of the righteous. Therefore, Jesus’ resurrection including the disappearance of his body should have taken place “in the twinkling of an eye”. This phrase means Jesus’ resurrection should have occurred very rapidly, probably in a very small fraction of a second, and not in minutes or hours or days. Thus, it is reasonable to assume the body disappeared over a time of between 1.0×10^{-9} second and 1.0 second. Anywhere in this range could be called “in the twinkling of an eye”, and yet would still be long in comparison to the time it would take electromagnetic radiation such as infrared or ultraviolet light to exit the body. The radiation must go through the remaining portion of the body, including the bones near the surface of the body, as the body disappears, so the information which defines the body’s appearance could be picked up by the radiation and be communicated by the radiation from the body to the cloth. This information must be communicated from the body to the cloth to control the discoloration mechanism so that it can form the image of the crucified man including the bones on the cloth⁸. Electromagnetic radiation, such as photons of infrared, visible, or ultraviolet light, travels at the speed of light (3.0×10^8 meters per second or about 186,000 miles per second), so it would traverse a body thickness of 20 cm in only $0.2 \text{ m} / 3.0 \times 10^8 \text{ m/s} = 6.7 \times 10^{-10}$ seconds. Particle radiation such as protons and electrons travels much slower. But even if protons or neutrons are not emitted with any additional energy but are simply left behind with a kinetic energy in equilibrium with their surroundings, i.e. at a thermal energy [0.0253 eV (electron volts)], their speed at the peak of the energy distribution would be 2200 m/s (meters per second)¹⁹, which is equal to 7218 feet per second. At this speed, it would take at most $0.2 \text{ m} / 2200 \text{ m/s} \sim 0.0001$ second for the protons or neutrons to get out of the body if they are travelling vertically. Even at this speed, a body disappearance time of 0.001 to 1.0 second would be slow relative to the time it would take for the radiation to exit the body, thus allowing the information content of the body’s appearance to be transferred to the cloth.

Where: If, as in #1 above, it is assumed the radiation was released by the process of the disappearance of the body, then it is reasonable to expect an equal amount of radiation to be released for each gram of body material that disappeared. With this recognition, and assuming the body was approximately a uniform density (gram/cm^3), then it follows the radiation would be emitted approximately homogeneously (uniformly) from within the body.

What: Regarding what kind of radiation would be emitted in the process of the disappearance of the body, it is probably best to initially consider the simple constituent parts of the atoms in the body (neutrons, protons, and electrons) and electromagnetic radiation such as photons of infrared, visible, or ultraviolet light. The much more complex option would be to consider all the other particles currently known in the standard model of

18. R. A. Rucker, “The Disappearance of Jesus’ Body, Part 1: Biblical and Theological Considerations”, October 8, 2016

19. Page 3 of <http://holbert.faculty.asu.edu/eee562/ThermalNeutronFlux.pdf>. Also, page 80-81 of *Nuclear Power Engineering* by M. M. El-Wakil, 1962

particle physics. And of course, the particle emission may have involved particles we know nothing about.

Why: Under the assumption it was Jesus' body that was wrapped in the Shroud, and the observers accurately reported (John 20:1-10) his body had disappeared from within the Shroud, then why would radiation be emitted in the disappearance of Jesus' body? By what mechanism would the radiation be emitted? We have no experimental data related to the disappearing of human bodies, except the Shroud, so these questions cannot be answered to our total satisfaction, except to note the disappearance of Jesus' body is best understood not as a disintegration of the atoms of the body but as a transition of the atoms of the body into an alternate dimensionality²⁰. The concept of a transition into an alternate dimensionality is consistent with various hypotheses in string theory developed in an attempt to solve problems in modern physics. In this way Jesus' body would continue to exist in the alternate dimensionality after the disappearance of the body from within the Shroud in the tomb. This most easily allows for the reports of Jesus' post-resurrection appearances because the body never ceases to exist. And if Jesus' body disappeared by a transition into an alternate dimensionality, then there is no basis to argue that radiation could not be released in the process, though we don't know the mechanism by which the radiation would be released. Our ignorance about how a particular event could have happened is not a proof the event could not have happened. What is possible needs to be determined from what has happened. As Spock, in his irrefutable logic, said to Captain Kirk: "That which has happened is possible" (Star Trek – Original Series, Third Season, episode 77, "The Savage Curtain").

How: Particles such as neutrons, protons, and electrons could have been emitted from the atoms as they transitioned into an alternate dimensionality. They also could have been merely left behind, having only the kinetic energy due to their being in thermal equilibrium with the surrounding material. Also, these particles could be secondary particles created by decay from other particles or they could result from basic energy differences between our dimensionality and the alternate dimensionality. Of course, electromagnetic radiation could also have been emitted by the process of the body disappearing. Because the front and dorsal images on the Shroud have good resolution, and because there are no side images, there must be a relationship of verticality between the body and the cloth which facilitates the vertical point-by-point communication of the information content that defines the body's appearance. This information must be communicated from the body to the cloth to form the image of the crucified man on the cloth⁸. Two explanations have been offered for this verticality:

1. The radiation that could have formed the image (charged particles and/or electromagnetic radiation) was emitted in vertically up and vertically down directions. Neutrons, because they have no charge, are very penetrating. This means if neutrons were involved in forming the image on the inside of the cloth, then the same image intensity would be formed all the way through the cloth as well as on the outside of the cloth. The evidence from the Shroud contradicts this, which

20. Robert A. Rucker, "The Disappearance of Jesus' Body, Part 2: Physical Considerations", October 11, 2016

proves neutrons were not a significant contributor to the formation of the image on the cloth. Thus, the neutrons could have been emitted in vertically up and/or down directions or they could have been emitted uniformly in all directions. The nuclear analysis computer calculations¹⁰ were based on the neutrons being emitted uniformly in all directions.

2. The cloth moved vertically (the upper cloth moving vertically down and the lower cloth moving vertically up) under the forces of gravity and air pressure difference immediately after the disappearance of the body. This is the “cloth collapse” hypothesis where the burial cloth collapses into the “radiant region” of the body during and/or after the body’s disappearance. Radiation encountered by the cloth in this radiant region then causes the discoloration on the cloth. There are unresolved problems with this image formation mechanism²¹.

The first of these two options is believed to be more likely correct, and so is selected for further consideration in the following.

6. Answers to Questions

In reference to the above working hypothesis, the following questions might arise:

1. The proposed hypothesis is that radiation was emitted from within a dead body as it was wrapped within the Shroud, which caused the front and dorsal images of the crucified man on the cloth. For this hypothesis to be real science, you have to know how the radiation was emitted within the body, what type of radiation it was, and what the energy level was. You then must be able to repeat the process in a laboratory under controlled conditions, with a dead body emitting radiation that encodes a good resolution front and dorsal image of itself onto a piece of cloth. If this is not done, then this is not science.

Response: This is a common objection to the approach taken in this paper to the investigation of the Shroud and arises due to certain false assumptions. The first assumption is that experimental science is the only type of science that exists. But various types of science can be discussed, with forensic science being used for the study in this paper. In forensic science, one follows the evidence where it leads without necessarily knowing or even being able to investigate the root cause. A detective investigating a murder scene uses this approach. The second assumption is naturalism, i.e. our current understanding of science is totally correct and absolute, so nothing new can ever be discovered to change our current laws of science. Thus, it is only legitimate to use our current understanding of science to explain all things including the image, date, and blood on the Shroud. But the history of science and the basic unsolved problems at the very foundation of physics argue strongly against this assumption. And since truth ought to be the goal of science, we must be willing to follow the evidence where it leads, even to the point of questioning our own basic assumptions. As a result, we need to foster an attitude of humility, curiosity, and willingness to “think outside the box” created by the constraints of naturalism. There are several good

21. Robert A. Rucker, “Potential Problems with a Cloth Collapse Hypothesis for Image Formation on the Shroud of Turin”, July 7, 2018

reasons to believe this approach will be necessary to solve the mysteries related to the image, date, and blood on the Shroud. These issues are considered further in the introduction²².

2. The time period over which the radiation is emitted is referred to as 0.00000001 to 1.0 second at one extreme for photons of electromagnetic radiation, down to 0.001 to 1.0 second at the other extreme for thermal particles. Are these the time intervals for a single burst of radiation or could there be multiple bursts of radiation?

Response: The above discussion, for simplicity, assumes the disappearance of the body, and the resulting radiation burst occurs linearly over the process. This means the density (g/cm^3) of the body linearly decreases over this short time so the radiation is emitted with a constant intensity over this same time interval. But admittedly, there could have been multiple shorter bursts of radiation corresponding to the disappearance of the body occurring in more of a stepwise time dependence. This would result in multiple shorter bursts of radiation possibly with the radiation being emitted alternating in up and down vertical directions. There is lack of certainty because of the lack of evidence from the Shroud.

3. You assume the radiation is emitted homogeneously from within the body. Since you are also assuming the radiation emission is caused by the disappearance of the body, this implies you assume the material within the body is also disappearing uniformly across the entire volume of the body. Is this the only option?

Response: This assumption was made for simplicity of the consideration, and for simplicity in computer calculations. We don't know the time or spatial dependence of the disappearance of the body or the resulting radiation emission, so we must remain flexible on these issues. Just as one very speculative example, the disappearance of the body could have resulted from a horizontal "activation plane" sweeping up and down through the body with the radiation being emitted perpendicular to the activation plane, and in the direction of motion of the activation plane, as it sweeps through the body. This would result in multiple radiation bursts with all the radiation oriented either vertically up or vertically down, thus causing the front and dorsal images. This is just one example of a process that could produce an image consistent with the evidence on the Shroud.

4. If protons were a significant contributor to image formation, can we ignore electrons?

Response: Probably not. Electrons would probably also be involved. This is because there would have been an equal number of electrons and protons in the atoms in the body. If we assume that in the disappearance of the body, a very small fraction of the atoms broke apart releasing their constituent parts (neutrons, protons, and electrons), then an equal number of electrons and protons would be released. Under this assumption, the number of neutrons released would be about 18% less than the number of protons, based on the number of neutrons vs. protons in the various elements in an average human body.

5. In this hypothesis with a single burst of radiation, would both the protons and electrons go vertically up and vertically down after being emitted from the body?

22. Also see Section 3 of "Status of Research on the Shroud of Turin" by Robert A. Rucker, July 16, 2020.

Response: This is uncertain. If the right electrostatic and magnetic fields were present, the electrons and protons might go in opposite directions because the electric charge of a proton (+1) is opposite to the electric charge of an electron (-1). For a single burst of radiation, this might explain why the discoloration of the dorsal image appears to be slightly lighter than the front image. In dealing with electric charge, opposite charges attract and like charges repel. If an equal number of protons and electrons were travelling in the same direction after the disappearance of the body, then there would be a strong attraction between them so, depending on the speed of the particles, there may have been a significant recombination into neutral hydrogen atoms, each of which contains one proton and one electron. Under this scenario, the opposite charges would cancel each other out. However, this scenario seems unlikely.

6. An objection to charged particles such as protons and electrons being a major contributor to the image formation is that an electric charge would build up on the cloth which could prevent additional charged particles from reaching the cloth, or could at least divert charged particles that did reach the cloth thus preventing an image with a good resolution. A sharp image can be obtained with electrons in a television tube because there is a return path for the electrons so a charge buildup does not occur, but there is no return path to prevent charge buildup on the Shroud.

Response: It is not certain a charge buildup could be sufficient to prevent additional charged particles from reaching the cloth, or even to prevent an image with a good resolution from forming. Perhaps this is a good area for future calculations and experiments. It is also not clear there is no return path for the electric charge to return from the cloth to the body during the short time interval of the disappearance of the body. Multiple options exist:

- The cloth was undoubtedly touching the body at many points. Charge could have flowed along the cloth from points where the cloth was not touching the body to points that were touching the body, and then could have flowed into the body thus dissipating the charge buildup on the cloth.
- If the image is formed by a static discharge⁴, then there could be a return path for the electric charge to flow from the cloth to the body on ionized air molecules that form in the air gap between the cloth and the body. This would be essentially a “lightning rod effect”. In a thunder storm, the bottom of the clouds become negatively charged and the top of the lightning rod becomes positively charged. If the charge difference is sufficient, a channel of ionized air, called a “leader”, develops between the lightning rod and the bottom of the cloud and when sufficiently developed, a lightning strike will proceed along the channel of ionized air from the cloud to the lightning rod. High speed photography shows most lightning strikes consist of from 3 to 30 electrical discharges going in both directions between the cloud and the lightning rod. This process results in extreme heating of the tip of the lightning rod. In the case of the Shroud, the high points along the top two or three layers of fibers in a thread would also experience a significant heating effect from the electrical discharge. Perhaps this heating of the high points along the fibers could have caused the discoloration of the outer layer of the fibers, resulting in a circumferential discoloration of the fiber⁴ to less than a thickness of 0.4 microns – less than a wavelength of light. The flow of electrons could also have directly caused the discoloration. The high points along the fibers being discolored is evidence an electric

discharge has occurred between the cloth and the body and/or the air, so a return path functioned to limit the charge buildup on the cloth.

- The discoloration could have occurred on the fibers before a sufficient charge had built up on the cloth to prevent additional charged particles from hitting it.

7. Can the above working hypothesis explain the 3D effect on the cloth?

Response: Yes. According to the hypothesis, the radiation is initially emitted approximately homogeneously from within the volume of the body. The radiation that caused the image (charged particles and/or electromagnetic radiation) would be initially emitted vertically up and down. After it exits the body, this radiation must travel across the air gap between the body and the cloth. While this radiation traveled across the air gap, the intensity of the radiation could be diminishing due to scattering, absorption, and possibly decay. The process would cause less discoloration for larger body-to-cloth gaps, thus causing the 3D effect on the cloth. The Shroud indicates there is no discoloration of the fibers for body-to-cloth gaps over about 3 or 4 cm.

8. In the discussion on the “How” of your working hypothesis, you say “The particles such as neutrons, protons, and electrons could have been emitted from the atoms as they transitioned into the alternate dimensionality. They also ... could result from basic energy differences between our dimensionality and the alternate dimensionality.” Could you explain?

Response: In reference to the first part of the quotation, the explanation and justification for the body transitioning into an alternate dimensionality results from a consideration of various options for the disappearance of the body¹⁹. In reference to the second part of the quotation, at one time atoms were thought to be the smallest indivisible unit of matter. Then it was discovered that atoms are composed of neutrons, protons, and electrons. For a long time, these were thought to be the smallest indivisible units of matter. Then it was discovered each neutron is composed of one up quark and two down quarks, and each proton is composed of two up quarks and one down quark. There are only four forces in nature: gravity, electromagnetism, the weak nuclear force, and the strong nuclear force. The three quarks in each neutron or proton are held together by the strong nuclear force, which is accomplished by the continual exchange of particles called gluons between the quarks. The standard model of particle physics identifies six types of quarks, each type of quark distinguished by a characteristic known as its "flavor". The six types of quarks, i.e. their six flavors, are: up, down, strange, charm, top, and bottom. These quarks are currently understood to be fundamental particles, which means they cannot be further divided into smaller particles. But because of this historical sequence, it might be suspected that quarks are also composed of smaller components just like atoms and then neutrons and protons were found to be composed of smaller components. The advocates of "string theory" believe everything including quarks are composed of much, much smaller one-dimensional lengths of vibrating energy called "strings", and all the characteristics (mass, charge, spin, etc.) of the sub-atomic particles that make up atoms and thus make up our physical reality results from the different possible vibration modes of the strings of which they are composed.

Thus, if a 170 pound man made a transition into an alternate dimensionality where all the atoms including all their neutrons, protons, and electrons transitioned into an alternate dimensionality but with the total mass-energy of each particle reduced by an average fraction

of 1.5×10^{-10} , then it is probable this would initially be left in our dimensionality in the form of energy (perhaps vibrating strings, with the lost mass converted to energy according to $E = MC^2$) which then very quickly would form into a wide variety of particles in our dimensionality, including photons and various flavors of quarks. The quarks would very quickly form into a variety of sub-atomic particles which would interact and decay until ultimately forming the most stable combinations of quarks, which are neutrons and protons. This would all happen so quickly it would be imperceptible. So, in an approximate sense, any energy not ultimately converted into neutrons and protons would be converted into photons such as infrared or ultraviolet light. I say "in an approximate sense" because many other types of particles may have been created and survived long enough to be of significance. The neutrons that are absorbed in N^{14} in the linen to create C^{14} may be secondary neutrons created by decay or interaction of other particles with matter rather than primary neutrons created directly from the energy left behind. We can't be sure what kind of radiation, whether particles or photons, were the most significant contributor to the discoloration on the linen. It may have even been radiation we know nothing about at this time.

9. The most common image formation hypotheses promoted by Shroud researchers are a static discharge, a photo-chemical process due to ultraviolet light, and a cloth collapse. How do the concepts discussed in this paper relate to these hypotheses?

Response: Radiation being emitted from the body which provides the energy for the discoloration mechanism and which carries the required information to the cloth does not require the discoloration mechanism to be either a static discharge or a photo-chemical process or a cloth collapse. It could be associated with any of these. But the above discussion has taken a static discharge as the most likely discoloration mechanism because there appears to be secondary images of the face and hands on the top side of the cloth that was above the body, i.e. on the reverse side of the cloth that was facing away from the body. If these secondary images are proven to not be present, and only appear to be present due to issues with human perception and expectations, then a photo-chemical process would become a more likely option. The cloth collapse hypothesis is judged to be less likely due to various objections²⁰.

7. Image Formation

The first observers to enter the tomb after Jesus' crucifixion and burial (John 20:1-10) claimed the body that was wrapped within the Shroud had disappeared from within the Shroud. If this is understood as a simple statement of eye-witness testimony, then it is an important clue as to how the image was formed. This event, which would have been outside of our current understanding of the laws of science, could have caused radiation to be emitted from within the body, consistent with the 17 arguments given above. Though there may be other methods, there appears to be two methods that radiation (charged particles or photons) could have caused the discoloration that makes the images on the Shroud:

1. The first option is where the energy of the radiation breaks the molecular bonds of an atom or group of atoms thus leaving an unbound electron in the outer carbon shell (orbit of electrons) which can then recombine with the surrounding atoms such as oxygen that

results in a change in the electron bonds of the carbon atoms. In this option, the discoloration is caused along the entire path length as deep as the radiation penetrates into the cloth as long as the energy of the radiation is sufficient. The problem with this scenario is where the discoloration occurs. Since it appears there is a real secondary image on the reverse or back side of the cloth, that was facing away from the body, if this first option was the cause, then the discoloration should occur across the thickness of the cloth rather than just on the inside and reverse side surfaces. This is because the radiation must penetrate through the cloth to discolor it on the reverse side of the cloth. The proposed photo-chemical process based on ultraviolet light⁷ is of this type. Thus, if there is a secondary image on the reverse or back side of the Shroud, and if the ultraviolet light caused it by a photo-chemical process, then the ultraviolet light should have caused discoloration across the thickness of the cloth, which is contrary to the evidence on the Shroud.

2. The second option is where the radiation knocks outer shell electrons out of the atoms in the air and the cloth through which it passes. This creates a positive charge distribution across the thickness of the cloth which then moves (electrically conducts) across the thickness of the cloth to collect on the highest sections of the fibers on both the inside and the outside surfaces of the cloth in response to the cloud of electrons in the air both on the front side (facing the body) and reverse or back side (facing away from the body) of the cloth. When sufficient charge difference is built up between these positively charged high sections of the fibers and the surrounding electrons in the air as they move toward the cloth by electrical attraction, a static discharge will occur between the high sections of the fibers and the surrounding cloud of electrons. This will cause a very significant electrical flow resulting in significant heating. One or both (electron flow or heating) may cause the change in the electron bonding of the carbon atoms in the cellulose molecule, and thus result in the discoloration. This is probably how the protons in Rinaudo's experiments⁵ caused discoloration. This second option assumes the energy of the radiation will be deposited across the thickness of the cloth, though as normally occurs, it will deposit more energy on the front (facing the body) of the cloth and diminish in intensity as it penetrates through the cloth. This would explain why the image is stronger on the front side of the cloth than on the reverse side of the cloth. Thus, this second option results in discoloration only on the inside and outside surfaces of the cloth, i.e. it is only a surface effect, which is consistent with the nature of the discoloration on the Shroud. This second option is called a static discharge⁴ and can be compared to lightning that passes between a charged cloud and an oppositely charged tip of a lightning rod, resulting in tremendous electron flow and heating of the tip of the lightning rod.

In this image formation hypothesis (#2 above), there could be a static discharge from both the front and reverse sides of the cloth due to the radiation going through the cloth. These electrical discharges could cause discoloration on both the front and reverse sides of the cloth. As the radiation went through the cloth, its intensity would diminish and scattering events from off atoms in the linen would tend to divert the radiation from an exactly vertical direction, which would decrease the resolution of the resulting image on the reverse side of the cloth. Both these predictions can be seen in the image of the face on the reverse side of the cloth: it is weaker in intensity than the image on the front side of the cloth, and it has poorer resolution.

8. Conclusions

In scientifically investigating the Shroud of Turin, we ought to strive to follow the evidence where it leads and not be constrained by a presupposition of naturalism. Based on this methodology, the evidence indicates the following. Three things are necessary for formation of the image on the Shroud: a discoloration mechanism, energy, and information. A discoloration mechanism must discolor the highest parts of the top two or three layers of fibers in a thread with a straw-yellow or sepia color circumferentially around the outside of the fibers that is less than 0.4 microns thick, and results from a change in the electron bonding of carbon atoms in the cellulose molecule. Energy is needed for the discoloration mechanism to function, i.e. to cause the change in the electron bonding of the carbon atoms. And information is necessary to control the discoloration mechanism so that front and dorsal images with good resolution are properly encoded onto the cloth. The content of this information must define the shape of the crucified man that was wrapped within the Shroud. This information must be based on the vertical distance of the body-to-cloth gap. This information must also include the location of bones near the surface of the body. And this information must be communicated to and deposited on the cloth. This can only be accomplished by radiation emitted within the body that passes through the air between the body and the cloth and is altered by this passage, thus communicating the vertical distance of the air gap to the cloth. To properly encode good resolution images onto the cloth, there must be a one-to-one correspondence between each point on the surface of the body and each point on the cloth. If there is no electric field strong enough to significantly affect the path of charged particles, then this can only be accomplished if the radiation is emitted from within the body in exact vertically up and vertically down directions. Thus, the role of radiation in image formation is two-fold: 1) to provide the energy required for the functioning of the discoloration mechanism, and 2) to carry the information from the body to the cloth required to control the discoloration mechanism so a good resolution image could be encoded onto the Shroud.

Seventeen reasons were given that radiation emitted from within the body is the most likely explanation for the image:

1. All other causes for the image have been disproven,
2. The color of the image and lack of fluorescence under UV light implies the image is a “cold” scorch due to radiation,
3. The front and dorsal images are on the inside of the wrapped configuration so the radiation must have come from the body,
4. The uniqueness of the image implies a unique cause,
5. Information must have been carried from the body to the cloth by radiation,
6. Bones are encoded into the images,
7. The front and dorsal images have good resolution, but there are no side images,
8. A static discharge is the best explanation for multiple unique characteristics of the image,
9. There is 3D or topographic information in the 2D image,
10. Upper fibers shield lower fibers from discoloration,
11. The front and dorsal images have a similar intensity,
12. The discoloration is due to altered electron bonds of carbon,
13. The image is due to the transfer of energy without substance, which is a good definition of radiation,

14. There is experimental evidence for protons and UV causing similar discoloration,
15. Neutrons emitted from the body explains the 1988 carbon dating,
16. The blood on the Shroud has a reddish color that could be explained by neutron absorption, and
17. Radiation pressure could possibly explain how the dried blood on the body was lifted off the body and thrust onto the Shroud.

To guide future research, a working hypothesis for radiation emission was developed. In this hypothesis, radiation is emitted by the process which causes the disappearance of the body, so the radiation is emitted homogeneously throughout the body, and the radiation ceases once the body has fully disappeared. The radiation is initially emitted in a vertical direction, being collimated vertically up and vertically down. For simplicity, it should initially be assumed the radiation is the components of the atoms (neutrons, protons, and electrons) and photons primarily in the infrared, visible, and ultraviolet energy range. Finally, an image formation hypothesis was stated based on vertically collimated radiation emitted from within the body potentially causing a static discharge on the top portions of fibers on the front side facing the body as well as possibly on the reverse side of the cloth, facing away from the cloth, consistent with dimmer less resolved images of the face and hands on the reverse side of the cloth, and darker better resolved images on the front side of the cloth facing the body.