

Holistic Solution to the Mysteries of the Shroud of Turin

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Abstract

The Shroud of Turin has been researched more than any other ancient artifact to solve its mysteries, which include the image on the cloth, the carbon date, and the blood. It would be attractive if, by following the evidence where it leads, a single concept, referred to in the title as a “holistic solution,” could be developed to explain these mysteries. This paper presents such an explanation. Based on the scientific evidence, it is hypothesized that an extremely rapid intense burst of radiation was emitted from within the body wrapped in the Shroud. Charged particles and/or electromagnetic radiation such as infrared, visible light, and ultraviolet in this burst of radiation can explain why we can see the image and how the image was formed. Neutrons in this burst of radiation can explain why carbon dating produced a date of 1260-1390 AD instead of the time of Jesus (30 to 33 AD). Neutrons might also explain why the blood has a reddish color. The extremely rapid outward pressure produced by this burst of radiation can explain how the blood was transferred onto the cloth and why the fibers under the blood are not discolored. Methods to test this hypothesis include measurement of the distribution of carbon dates across the Shroud and detection of long half-life isotopes (Cl-36, Ca-41) on the threads and blood on the Shroud and in the proposed limestone tombs.

1. Introduction

This paper documents the presentation with the above title delivered at the 2019 International Conference on the Shroud of Turin, August 14 to 17, 2019 at the Redeemer University College in Ancaster, Canada. Background for the information discussed here is available in the author’s previous papers¹ which are available on the research page of his website www.shroudresearch.net.

It is essential to use the proper methodology in researching the Shroud. To the extent possible, the researcher should recognize his own biases and presuppositions, so these will not affect his judgment so objectivity can be maintained. In other words, research should be performed with a neutral mindset, i.e., it should be assumed that the Shroud of Turin may or may not be Jesus’ burial cloth, God may or may not exist, Jesus’ resurrection may or may not be a real historical event, and the Shroud may or may not have experienced a unique event that is outside or beyond our current understanding of the laws of physics. This last point is the issue of naturalism. As used here, naturalism is defined as the assumption that the only explanations allowed are those consistent with the known laws of science, so nothing outside of science, as we now understand it, is possible. Naturalism has been discussed more fully elsewhere.² The methodology for researching the Shroud advocated here could be called forensic science or

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1. Robert A. Rucker: “Summary of Scientific Research on the Shroud of Turin”, Rev. 3, Nov. 14, 2018, “Explaining the Mysteries of the Shroud”, Rev. 5, Nov. 14, 2018, “Status of Research on the Shroud of Turin”, July 16, 2020.
 2. Section 3 of “Status of Research on the Shroud of Turin” by Robert A. Rucker, July 16, 2020

reverse engineering. In simple terms, it is following the evidence where it leads, without the restrictions of presuppositions, either religious or naturalistic.

In following the evidence where it leads, we are led to the hypothesis that there was an extremely rapid intense burst of radiation from the body that caused the image. If neutrons were included in this burst of radiation, they would have shifted the carbon date in the forward direction, potentially explaining the 1988 carbon dating of the Shroud. If this radiation burst was sufficiently brief and intense, it could have thrust the dried blood off the body onto the cloth, caused the blood to retain a reddish color without discoloring fibers below the blood, and might have even elevated the upper cloth above the body, as will be discussed below. Thus, the hypothesis of an extremely rapid intense burst of radiation from the body is proposed to explain the mysteries of the Shroud related to the image, the carbon dating, and the blood on the cloth. It is the only single hypothesis that has been proposed to explain these mysteries.

2. The Shroud Wrapped the Body of a Crucified Man

We approach this issue by briefly reviewing the history of research on the Shroud. Research started in 1898 when Secondo Pia took the first photograph of it. To his shock, when he developed the glass plate from his camera, what he expected to be a low-resolution negative image turned out to be a high-resolution positive image. This revealed that the image on the Shroud was like a negative image, with the dark and light areas reversed. Thus, the image could not be a painting, which contradicted most people's belief in 1898. An artist could not have painted a negative image hundreds of years ago because he had never seen one, or even heard of the concept. If the image was not produced by an artist, and there appeared to be no other realistic option to form it, then the image was apparently produced by the body wrapped in the Shroud. The fact it wrapped a crucified body was confirmed over the next seven decades as researchers primarily studied the nature of the blood on the cloth. The main researchers in this period were:

- Dr. Yves Delage, Prof. of Comparative Anatomy, Paris 1900-1902
- Dr. Paul Vignon, Professor of Biology, Paris 1900-1943
- Dr. Pierre Barbet, Prof. of Anatomy, Paris 1932-1961
- Dr. Robert Bucklin, M.D, Forensic Examiner, LA 1941-1993
- Dr. Frederick Zugibe, Chief Medical Examiner, NY 1953-2002

These researchers all had doctorate degrees, many with specialties in anatomy, wounds, and blood. Several of them researched the Shroud for multiple decades. They concluded that the blood came from a real crucified body that was wrapped in the Shroud, based on the pristine nature of the blood, the shape of solidified blood components, and the presence of halo rings around these components that are only visible under ultraviolet light.

Dr. John Jackson was a professor of physics at the Air Force Academy in Colorado Springs, Colorado. In the early 1970s, when he placed a photograph of the face on the Shroud under an electronic device called a VP8 Image Analyzer, it was discovered that the image on the Shroud contains 3D information. This 3D information that is recorded on the Shroud represents the vertical distance from the body to the cloth in the wrapped configuration. No other painting or photograph contains 3D information. This amazing discovery led to the establishment of the Shroud of Turin Research Project (STURP). In 1978, the Vatican invited STURP to perform

experiments on the Shroud of Turin in the Cathedral of St. John the Baptist in Turin, Italy, for five days, 24 hours a day. The only restriction was the Shroud should not be damaged in the process.

STURP's main goal was to determine the cause of the image. STURP concluded that they found no evidence of pigment causing the image. They also found no carrier, no capillarity (soaking up of a liquid), nothing clumping fibers or threads together, no cracking of the image along fold lines, no brush strokes, and no stiffening of the cloth. This evidence indicates the image is not due to paint, dye, or stain. The lack of capillarity indicates the image could not be due to an acid or any organic or inorganic chemical in liquid form. Under UV light, the scorches on the Shroud from the fire in 1532 fluoresced, but the body image did not. This indicates the image is not a scorch from a hot object. The evidence also argues against the possibility the image is a photograph:

- There are full-size front and back images of a crucified man on the Shroud. The photographic negative shows these as positive images with good resolution. These images contain 3D information related to the vertical distance from the body to the cloth. No photographs of any other objects contain 3D information.
- There is extreme superficiality of the discoloration in the fibers. Only the top two or three fiber layers in a thread are discolored, and the discoloration in a fiber is less than 0.4 microns thick around the circumference of the fiber, which has a diameter of about 15 microns. The inside of the fiber is not discolored. These characteristics are contrary to a photograph.
- The discoloration in this very thin layer is caused by a change from single electron bonds to double electron bonds in the carbon atoms in the cellulose. This is contrary to a photograph. A change from single to double electron bonds can result from the process of oxidation and dehydration associated with aging of linen, though normal aging of linen does not produce the image of a crucified man.
- There is no evidence of capillarity (soaking up of a liquid) in the fibers or threads, so no liquids were used in the process of forming the discoloration in the fibers. The photographic process uses liquids to develop an image on film and on photographic paper.
- The discoloration of the fibers is mottled, and fibers under the blood are not discolored. Again, these are not characteristics of a photograph.
- No residual material was found on the Shroud from a photographic process.
- For such a hypothetical photographic process to be correct, it had to form the image prior to about 1355, when the Shroud was displayed in Lirey, France. Evidence on the Hungarian Pray Manuscript indicates this date should be pushed back to at least 1192-1195. Evidence on coins and paintings indicates this date should be pushed back to about 550 AD. It was not until 1826 that the first photograph was produced.
- If a photographic process was used to produce the image on the Shroud prior to these dates, it is strange that it was not used to produce any other image in the many centuries since.
- No hypothesis has been suggested that is consistent with both the macroscopic evidence (how the image looks) and all the above microscopic evidence (the very small-scale characteristics) of the image. If a hypothesis is not consistent with all the above evidence, it cannot be correct.

The absence of body decay products on the cloth indicates the image was not caused by decay products interacting with ointments. The bottom line is that after five days, 24 hours a day of experiments, researchers could not explain how the image was formed. STURP's conclusion in 1981 was, "We can conclude for now that the Shroud image is that of a real human form of a scourged, crucified man. It is not the product of an artist." Based on the above evidence, the most reasonable conclusion is that the image was formed by the body of the scourged crucified man as it was wrapped in the Shroud. This agrees with the first seven decades of research that concluded the blood now on the Shroud came from a dead human body wrapped in the cloth. Thus, both the blood and STURP's experiments indicate the image and the blood on the cloth are the results of a real crucified man. There is no realistic alternative. A forger could not create such an image.

3. Why can we see the Image?

Regarding the mystery of the image on the Shroud, it is important to break this into two sub-issues. Why we can see the image should be distinguished from how the image was formed. Answering the first question (Why can we see the image?) will help us answer the second question (How was the image formed?).

Information is the key to understanding why we see the image³, both how information is stored and how it is transported from one location to another.⁴ As an example, how is it possible for one person to see another person? The smallest packet of energy that makes up light is called a photon. Photons can carry, transfer, or communicate information in three ways. A photon's energy communicates color. Its intensity (number of photons) communicates shade (light vs. dark). The position and angle the photon enters the lens of a person's eye communicates the position of the color and shade of the point being seen. Thus, person A can see person B because the color, shade, and position of every point on person B is communicated to the eyes of person A by photons that reflect off person B. In fact, every image that a person sees whether in a photograph, magazine, newspaper, television, computer monitor, or in the scene in front of his eyes is based on information. For example, the person in a photograph can be recognized because the information that defines the person's appearance has been encoded into the location of the pixels/dots on the photograph. This information is communicated to the person looking at the photograph by reflected photons.

This principle can be applied to the image on the Shroud. The pixels that make the image of the crucified man consist of the top fibers in certain linen threads that have been discolored into a straw-yellow or sepia color. We recognize this image because the information that defines the appearance of a crucified man has been encoded into the pattern of the discolored fibers on the cloth. This information had to be deposited on the Shroud to be encoded into the image. It had to be transported or communicated to the cloth from somewhere else. Since the content of this information is that which defines the appearance of a naked crucified man, it could only come from one place. It could not have come from the air or limestone in the tomb since this information was not inherent to those locations. It could only have come from the body because this information was only inherent to that body. Thus, this information had to be transported from the body to the cloth and deposited there. Photons of infrared, visible, and ultraviolet light can transport such information by their energy, intensity, and direction. Charged particles, such

3. Robert A. Rucker, "Why we Can See the Image on the Shroud", June 29, 2020

4. Robert A. Rucker, "Information Content on the Shroud of Turin", Oct. 11, 2016

as protons or electrons, have the same capability. In fact, of the various means of transporting information from one location to another, such as sound waves, electron flow in wires, diffusion of molecules, etc., only radiation could have transported the focused information from the body to the cloth that is needed to form the good resolution image.⁵ This radiation could have consisted of charged particles, such as protons or electrons, and/or photons of electromagnetic radiation such as infrared, visible, or ultraviolet light.

4. How was the Image Formed?

To summarize, the above evidence indicates that the dead body of a crucified man was wrapped in the Shroud. This body in some way produced the image. Its formation required the transfer of information from the body to the cloth. This information had to define the appearance of a naked crucified man because that is what the image is. This information could only have come from the body and could only have been transported from the body to the cloth by radiation. We next look at the details of the process to establish the requirements that must be met.

The Shroud is a 3-to-1 Herringbone weave of linen threads, with each thread composed of about 200 fibers, with the discolored fibers in only the top two or three layers of fibers in a thread. It is these discolored fibers that form the image of a crucified man. With the Shroud, a person must be several feet back from the cloth to see the image, whereas in most paintings or photographs, the details are sharper at a close distance. The discolored fibers appear in groups with some areas of the threads discolored and other areas not. This mottling effect of the discolored fibers is an aspect of the image that needs to be explained.

Research by STURP determined that: 1) of the fibers on the side of the thread facing the body, only the top two or three layers of fibers are discolored, 2) there is nothing clumping the fibers together so the image could not be due to paint, dye, or stain, and 3) there is no evidence of capillarity from one fiber to another, which means that a liquid was not involved in making the image. How could only the top two layers of fibers in a thread have been discolored without clumping or use of a liquid?

The extreme superficiality of the discoloration is also indicated by the location of the discoloration. A linen fiber is about 15 microns in diameter, about one-fifth the diameter of a human hair. A micron is a millionth of a meter, which is equal to a thousandth of a millimeter (1 micron = 0.000001 meter = 0.001 mm). The straw-yellow to sepia color is located only in the outer 0.4-micron thick surface layer around the circumference of the fiber with the inside of the fiber not discolored. The thickness of this discolored layer is probably more accurately described as 0.2 ± 0.2 microns.

The discoloration in this thin layer is caused by a change in the arrangement of the atoms that were already in the cellulose, rather than by the addition of new atoms. Carbon atoms have two electrons in their inner orbit and four electrons in their outer orbit. Each of these four outer orbit electrons is normally bound to one other atom in cellulose, which causes the carbon atom to vibrate in a certain way. But in the thin discolored layer, some of the carbon atoms are only surrounded by three other atoms. This means that of the four outer orbit electrons, one electron is bound to one adjacent atom, another electron is bound to a second adjacent atom, but two electrons are bound to the third adjacent atom. This change from single electron bonds to a double electron bond causes the carbon atoms to vibrate differently so that we see a different

5. Robert A. Rucker, "Role of Radiation in Image Formation on the Shroud of Turin", July 16, 2020

color reflected from them. What could cause such a change from single electron bonds to double electron bonds in a very thin layer in a fiber to produce the image of a crucified man?

It is the pattern of these discolored fibers that form the good resolution image of the face, with characteristics of a negative image that contains 3D information. The pattern of discolored fibers also formed the entire front and back images of the body. How could the fibers have been discolored in the precise pattern to create these images? The mechanism that formed the front and back images did not encode the sides of the body or the top of the head onto the cloth.

Three things are required to form the image. 1) There must be a process or mechanism to discolor the fibers. 2) Energy must be provided to drive the discoloration mechanism to change carbon atoms from single to double electron bonds. 3) Information must be provided to the discoloration mechanism to control which fibers are discolored and the length of that discoloration so that the image could be formed. No image could have been formed without the proper information to control the discoloration mechanism. A burst of radiation from the body could have transported both the energy and the information to the cloth.⁵ Thus the image was formed by radiation controlled by information.

A paper⁶ published in the March 20, 2019; issue of *Applied Optics* includes an image of the face on the Shroud that is significantly better than any previous attempt to replicate the image. It was produced by radiation controlled by information, as advocated above. In this research, a laser was used to emit a femtosecond pulse of infrared light. A femtosecond is an extremely small fraction of a second: one femtosecond = 10^{-15} second = a millionth of a billionth of a second. Previous experiments⁷ with an ultraviolet laser indicate that the laser pulse must be extremely rapid to produce the degree of superficiality that exists on the Shroud with only the top two or three layers of fibers discolored.

The above evidence can be assembled into a proposed hypothesis to explain how the image was formed.⁸ The dead body of a crucified man was wrapped in the Shroud. This body caused both the blood and the image on the cloth. The image was formed by something that flowed from the body to the cloth across the air gap between the two:

1. As the body was wrapped in the Shroud, the cloth would have been touching the tip of the nose but not the side of the nose at the nostrils, yet there is a smooth gradation of discoloration down the nostrils. This means that the discoloration could not be the result of contact with the cloth. It had to be caused by something that flowed across the air gap between the body and the cloth.
2. Upper fibers and threads in the image shield lower ones from discoloration. This again implies that something flowed from the body to the cloth, with the upper fibers and threads preventing it from getting to the lower ones.
3. We can see the image because the information that defines the appearance of a crucified man has been encoded into the pattern of discolored fibers in the image. This information had to be transported from the body to the cloth to control the discoloration mechanism that formed the image. Radiation is the only realistic option to transport this information.⁵ Radiation, both particles such as protons and electrons and electromagnetic radiation such as infrared,

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., "Superficial and Shroud-like Coloration of Linen by Short Laser Pulses in the Vacuum Ultraviolet", January 2013

8. Robert A. Rucker, "Image Formation on the Shroud of Turin", Rev. 1, July 14, 2019

visible, and ultraviolet light, can transport information by their energy, intensity, and direction.

4. There is 3D information in the image. This 3D information is related to the vertical distance from the body to the cloth across the air gap, with no discoloration of the fibers if the air gap is over about three or four centimeters. This 3D information effect would naturally result if whatever flowed from the body to the cloth diminished as it traveled across the air gap. Radiation emitted in the body would naturally diminish as it went across the air gap due to absorption and scattering in the air. Particle radiation could also decrease due to decay.

Based on the above evidence, the image formed when an extremely rapid intense burst of radiation was emitted from the body. This radiation transported the energy and information to the cloth that was required to form the image. It had to be an extremely rapid burst to produce the superficiality of the image. This radiation probably consisted primarily of charged particles such as protons and electrons, although electromagnetic radiation such as infrared, visible, and ultraviolet light could also have been involved. Highly penetrating radiation such as neutrons, X-rays, and gamma rays were not significant contributors to the image formation. If they had been, then there would be an image with a similar intensity on the side of the cloth away from the body, which is not true for the Shroud.

Since there would have been no lens between the body and the cloth to focus the radiation to form the good resolution image, the radiation had to be vertically collimated as the body lay horizontal in the tomb. "Vertically collimated" refers to the radiation being emitted exactly vertically up and vertically down from the horizontal body. This is necessary so that each point on the front and back images received radiation, and hence information, from only one point on the body. If the radiation was not vertically collimated relative to the horizontal body, then each point on the cloth would have received radiation, and hence information, from multiple points on the body. This might have caused random discoloration on the cloth but no image. The vertical collimation of the radiation also explains why there are no images on the Shroud of the sides of the body or the top of the head.

How the fibers were discolored can be explained by an extremely rapid intense burst of charged particles that created a high electrical charge on the cloth in a small fraction of a second. If the radiation burst were rapid and intense enough, it would have caused an electrical discharge from the high points of the fibers facing the body. This electrical discharge from the fibers would have involved an extremely high electrical current in the fibers, with the electrons flowing primarily near the outer circumference of the fibers as a high electrical current normally does in a conductor. This would have produced extreme heating around the outer circumference of the fibers, which could have damaged the atomic structure of the cellulose in this region, exactly where the fibers are discolored. The static discharge could also have formed ozone, which could also have damaged the cellulose around the circumference of the fibers.

The mottled appearance of the discolored fibers, with some areas of the threads discolored and others not, can be explained as a "lightning rod" effect. When a thunder cloud passes over an area of level ground containing many lightning rods, lightning will strike where the distance between the cloud and a lightning rod is a minimum. The lightning between the cloud and the tip of the lightning rod will produce a significant electrical flow in the ground and in the clouds so the surrounding area in the ground and in the clouds is discharged. As a result, lightning will probably not strike in the immediate area again. The same principle holds for the electrical discharge from the top fibers of the threads in the Shroud, resulting in areas of the threads that

are discolored and others not. This effect, as well as scattering of the radiation by the air between the body and the cloth, would cause some loss in the resolution of the image, as seen on the Shroud.

Both the electrical heating and the possible ozone could damage the atomic structure of the cellulose in the outer circumference of the fibers. It is believed, with the passage of time possibly combined with exposure to ultraviolet light in sunlight, this region of damaged cellulose in the outer circumference of the fibers gradually became discolored by an oxidation-dehydration process that caused some of the single electron bonds of the carbon atoms in the cellulose to be changed to double electron bonds. This change in the electron bonding of the carbon atoms causes the appearance of the straw-yellow or sepia color in the image. This process was very selective in that it created the image of a crucified man, based on the information deposited on the cloth. If this scenario is correct, then the image may not have formed immediately after the burst of radiation from the body but could have perhaps taken weeks, months, or years to form. The attractiveness of this proposal for image formation is that it can explain all the characteristics of the image: a negative image on the inside of the wrapped configuration that contains 3D information, extreme superficiality of the image, color due to a change in the electron bonding of carbon atoms in the cellulose, mottling of the threads, and the upper fibers and threads shielding lower ones from discoloration.

5. What is the Date of the Shroud?

The dating of the Shroud is a common objection to its authenticity. It is often said the Shroud only dates to about 1355 AD. A correct understanding is that the continuous history of the Shroud only goes back to about 1355 or 1356 when it was shown as the burial cloth of Jesus in Lirey, France. However, when it is realized that the 1260-1390 date obtained by carbon dating should be rejected (see the next section), there is no reason the Shroud could not date to the first century. This is based on historical evidence especially the Pray manuscript, traditions, physical evidence, and the many other date indicators for the Shroud.⁹ It was evidently well known and revered in Constantinople for hundreds of years before 1204. It was probably also in Edessa and Jerusalem before that. Thus, the Shroud could go back to the time of Jesus, about 30 AD.

6. What About the 1988 Carbon Dating?

In 1988, samples were cut from the lower corner of the Shroud of Turin for carbon dating. The result of this process was a date range of 1260 to 1390 AD, with a 95% probability the true date falls within this range.¹⁰ This is often assumed to be the strongest evidence the Shroud dates to the 13th or 14th century and so could not be the burial cloth of Jesus. However, there are many reasons this date should be rejected.¹¹ Carbon dating involves a two-step process. The carbon-14 to carbon-12 (C^{14}/C^{12}) ratio of a sample is first measured. This measured ratio is then used to calculate a date for the sample assuming the C^{14}/C^{12} ratio has only changed due to decay of the C^{14} . Proper statistical analysis of the data resulting from the carbon dating indicates there was probably an unexpected factor that altered the C^{14}/C^{12} ratio in the samples. This means the

9. Robert A. Rucker, "Date of the Shroud of Turin", July 16, 2020

10. P.E. Damon and 20 others, "Radiocarbon Dating of the Shroud of Turin", *Nature*, February 16, 1989.

11. Robert A. Rucker, "Carbon Dating of the Shroud is Explained by Neutron Absorption", July 14, 2020.

C^{14}/C^{12} ratio for the samples was correctly measured, but because this ratio had been altered by an unexpected factor, the calculated date was not the true date for the Shroud. This difference between the calculated date and the true date is called a systematic error or bias. Since the magnitude of this error cannot be determined, the conclusion of the 1988 carbon dating of the Shroud should be rejected, i.e. the date of 1260-1390 AD should be given no credibility. Three recent statistical analyses of the data agree with this conclusion.¹²

Several options have been proposed for the cause that altered the C^{14}/C^{12} ratio of the samples, including heat and smoke from the fire in 1532, contamination, bioplastic film, an invisible reweave, and carbon monoxide. All these options have significant problems. Another option which would cause the carbon date to be different from the true date is neutron absorption. This was one of the earliest documented proposals¹³ to explain how the C^{14}/C^{12} ratio of the samples was altered. This explanation nicely correlates with the above concept that the image on the Shroud was produced by a burst of radiation from the body. Experiments have shown protons can cause discoloration on linen similar to what is seen on the Shroud.¹⁴ If charged particles, such as protons, were emitted from the body to form the image, then it is possible neutrons were also emitted in this burst of radiation because there is a similar number of neutrons and protons in the body. For example, about 10% by weight of a human body is hydrogen. About 99.98% of hydrogen atoms have only a proton in the nucleus of the atom (H^1), and about 0.02% of hydrogen atoms have both a proton and a neutron in the nucleus. The form of hydrogen that contains both a proton and a neutron is called deuterium or heavy hydrogen (H^2). Therefore, if protons in the radiation burst resulted from splitting of deuterium nuclei, then an equal number of neutrons and protons would be emitted. Deuterium is of special interest because it requires the minimum energy to split its nucleus into separate neutrons and protons.

The human body is made of organs, which are made of proteins. These proteins are composed of molecules containing atoms, which contain neutrons, protons, and electrons. An average human body contains about 2×10^{28} neutrons. To analyze the possibility of neutron emission from the body, nuclear analysis calculations were performed using the MCNP (Monte Carlo N-Particle) computer software. These MCNP calculations determined if 2×10^{18} neutrons were emitted homogeneously in the body, it would cause a 16% increase in the C^{14} content at the 1988 sample location by the [$N^{14} + \text{neutron} \rightarrow C^{14} + \text{proton}$] reaction. This 16% increase would cause the carbon date to shift from 30 AD to 1260 AD, thus explaining the 1988 carbon dating of the Shroud. The 2×10^{18} neutrons would be produced by splitting only 0.0004% of the deuterium nuclei in the body. Emission of 2×10^{18} neutrons is only one neutron for every ten billion neutrons in the body ($2 \times 10^{18} / 2 \times 10^{28} = 1 \times 10^{-10}$).

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12. T. Casabianca, E. Marinelli, G. Pernagallo, and B. Torrisi, "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, and Paolo Di Lazzaro, Anthony C. Atkinson, Paola Iacomussi, Marco Riani, Marco Ricci, and Peter Wadhams, "Statistical and Proactive Analysis of an Inter-Laboratory Comparison: The Radiocarbon Dating of the Shroud of Turin", *Entropy*, August 24, 2020
 13. Thomas J. Phillips, "Shroud Irradiated with Neutrons?", *Nature*, Vol. 337, No. 6208, page 594, February 16, 1989, published in the same edition of *Nature* as Damon.
 14. Arthur C Lind, "Image Formation by Protons", available at <https://www.testtheshroud.org/articles>

7. The Blood on the Shroud

The first seven decades of Shroud research were concerned primarily with issues related to the blood. Much of the blood would have dried on the body before it was wrapped in the Shroud, so why is it now on the cloth? This is mysterious because dried blood does not soak into cloth.

The hypothesis of an extremely rapid intense burst of radiation emitted in the body raises an interesting possibility. Particles that have mass also have momentum as they move. Electromagnetic radiation such as infrared, visible, and ultraviolet light also have momentum. When this momentum from either particles or electromagnetic radiation is absorbed and thus transferred to an object, it can cause the object to move. This is referred to as radiation pressure and has multiple applications from a Crookes radiometer (also known as a light mill) to a solar sail for propelling a spacecraft. The point is a burst of radiation emitted within the body, as hypothesized here, if sufficiently rapid and intense, and if vertically collimated both up and down, could force the dried blood off the body, accelerate it vertically away from the body without scattering it, and thrust it onto the cloth. The result would be the blood as we now find it on the Shroud.

Other mysteries related to the blood are the following. Why is the blood still a reddish color when blood exposed to air quickly turns dark brown to black? Within the area of the image, why are fibers under the blood not discolored? Lastly, why does the image of the face appear to have been encoded onto a flat surface instead of a curved surface as the cloth wrapped around the face?

Based on recent experiments by Kelly Kearse, high quantities of bilirubin in the blood will not cause it to retain a reddish color, as is often believed. Previous experiments by Carlo Goldoni¹⁵ indicate neutron absorption in blood followed by exposure to ultraviolet in sunlight can cause blood to retain a reddish color. This evidence was not well documented and should be confirmed. If neutrons were included in the hypothesized burst of radiation from the body, as in the neutron absorption hypothesis, then some of them would have been absorbed in the blood, which may have caused it to retain its reddish color. If momentum and thus energy in the radiation was deposited in the blood to force it off the body and onto the Shroud, there may have been insufficient energy remaining in the radiation to discolor the fibers under the blood, thus possibly explaining why the fibers are not discolored in those locations. Electrostatic forces involved in this process may also explain why the image looks as if it was encoded while the cloth was flat above the body, with no distortion of the image due to the cloth wrapping around the body.

8. Conclusion

By following the evidence where it leads, apart from religious or naturalistic presuppositions, a hypothesis was developed to explain the mysteries of the Shroud including the image, date, and blood. This hypothesis proposes an extremely rapid intense burst of radiation was emitted within the body of a crucified man as it was wrapped within the Shroud. This radiation traveled from the body to the cloth where it deposited the energy and information required to form the image. The energy was required to change the electron bonds in the

15. 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

cellulose to discolor the fibers. The information was required to control where fibers had to be discolored to form the image. To form the good resolution images of the front and back of the body, without lenses between the body and the cloth, the radiation had to be collimated both vertically up and vertically down from the horizontal body as it lay in the tomb. This would also explain why there are no side images of the body on the Shroud.

The radiation that caused the image was probably charged particles, such as protons and electrons, and/or electromagnetic radiation such as infrared, visible, and ultraviolet light, but not highly penetrating radiation such as neutrons, X-rays, or gamma rays. It is proposed the charged particle radiation very rapidly produced an extremely high electrical charge buildup on the cloth, which produced an electrical discharge from the top fibers facing the body. This produced an extremely high electrical current flow, which produced extreme heating that damaged the thin outer layer on the circumference of the fibers. This led to discoloration of the fibers that formed the image. The possible production of ozone might also have led to a chemical attack on this thin outer region of the fibers.

If neutrons were also present in the burst of radiation, some of them would have been absorbed in the trace amount of N^{14} in the cloth to produce new C^{14} in the Shroud. This would have shifted the carbon date forward up to thousands of years, depending on the location on the cloth. This would explain the 1988 carbon dating of the Shroud. This neutron absorption hypothesis can be tested using the predicted distribution of the carbon dates on the Shroud¹⁶, and possibly by detecting long half-life isotopes (Cl-36, Ca-41) in threads from the Shroud and in limestone from the tomb. The neutrons would have also been absorbed in the blood, which may have caused the blood on the Shroud to retain a reddish color. The burst of collimated radiation, if sufficiently brief and intense, could have thrust the dried blood off the body onto the cloth. In transferring momentum and energy to the blood to move it, the remaining energy in the radiation might have been insufficient to discolor fibers. This is consistent with the fibers under the blood not being discolored. The electrostatic forces involved in this process may be helpful to understand why the top cloth appears to have been flat above the body since there appears to be no distortion effects on the image from the cloth wrapping around the body.

Thus, the hypothesis of an extremely brief intense burst of vertically collimated radiation emitted within the body is attractive because it explains the mysteries of the Shroud regarding the image, the carbon dating, and the blood. Specifically, it can explain why:

1. The image is on the side of the cloth that was facing the body.
2. The image has a good resolution, without images of the sides of the body or the top of the head.
3. There is an image where the cloth would not have been touching the body.
4. The front and back images are of equal intensity.
5. The image is a negative image.
6. The image contains 3D information related to the vertical distance from the cloth to the body.
7. Only the top two or three layers of fibers are discolored in a thread.
8. Only a very thin outer region less than 0.4 microns thick on any fiber is discolored.
9. Discoloration in the fibers is caused by carbon atoms in the cellulose being changed from single to double electron bonds.

16. Robert A. Rucker, "Proposal for C^{14} Dating of Charred Material Removed from the Shroud", October 15, 2018, Figure 1.

10. Upper threads and fibers shield lower ones.
11. The discoloration is mottled on the threads.
12. The 1988 carbon dating produced a 1260-1390 date for cloth from the first century.
13. The blood on the Shroud has a reddish color.
14. The blood that would have dried on the body is now on the cloth.
15. Fibers are not discolored under the blood.
16. The image of the face does not show distortion due to the Shroud wrapping around his head.

Papers by Robert A. Rucker are available on the research page of www.shroudresearch.net.