

# Criteria for Evaluating Image Formation Hypotheses for the Shroud of Turin

Robert A. Rucker, MS (nuclear engineering)  
Rev. 0, January 18, 2024, Rev. 1, May 23, 2024

## Abstract

Multiple hypotheses have been proposed to explain how the front and dorsal images of a crucified man were formed on the Shroud of Turin. This paper recommends criteria for judging the merits of a particular image formation hypothesis. Criteria include: 1) the hypothesis must be consistent with all the scientific evidence that is true about the images, 2) the hypothesis should make predictions that are testable, falsifiable, and possibly unique, and 3) a hypothesis is preferred over other hypotheses if it: a) explains multiple aspects of the Shroud, b) is simple rather than complex, c) is recognized as having “beauty”, d) considers aspects of the Shroud that the hypothesis does not explain, e) is corroborated by one or more diverse areas of study, and d) clearly discusses how information was used to form the images. As examples, these criteria are applied to a generic scorch hypothesis and to the specific hypothesis that the images on the Shroud were formed by roasting of flour and oil on a statue or bas relief.

## 1. Introduction

In general terms, a hypothesis is a proposed concept for explaining observations about a phenomenon. The Shroud of Turin is a linen cloth that contains front and dorsal images of a crucified man. This paper will consider the criteria that should be used to judge the merits of the various hypotheses to explain how these images were formed on the Shroud of Turin. Many people seem to think that if an image formation hypothesis provides evidence for a mechanism that can discolor linen fibers, that this hypothesis must therefore be how the images were formed on the Shroud. However, the fact that a particular hypothesis has been proposed does not make it true. A particular hypothesis could be judged by different researchers to be true or not in the following ways. It could be judged to be: 1) definitely not true, 2) probably not true, 3) possibly true or not true, 4) probably true, or 5) true beyond a reasonable doubt. Different researchers could take different positions among these options. According to the scientific process, a conclusion of the truth of a particular hypothesis requires a consensus of expert opinion, and even with such a consensus, the conclusion should often be held with a degree of tentativeness to allow for future new evidence.

How a hypothesis reproduces the face on the Shroud is often thought of as the best test, in a macroscopic sense, of whether the hypothesis could be true. In researcher’s attempts to develop image formation hypotheses, the best image of the face on the Shroud was produced by radiation controlled by information (Figure 7c in Ref. 1). The image formation hypothesis in Ref. 2 also proposed that the images were formed by radiation controlled by information. Information was necessary to control which fibers were to be discolored and the length of that discoloration so that the images could be formed on the Shroud. How the information required to control the image formation process was delivered to the Shroud should be discussed in an image formation hypothesis.

## 2. Scientific Evidence Related to the Images

For a hypothesis for image formation to be true, it must be consistent with the scientific evidence related to the images. This includes both the macroscopic (large scale, how it looks) evidence and the microscopic (very small scale) evidence. Previous lists of the scientific evidence related to the images on the Shroud are in Ref. 3 and 4. The 27 evidences related to the images that were used to develop the Vertically Collimated Radiation Burst (VCRB) hypothesis (Ref. 2) for image formation are listed below. These 27 evidences will be applied below in Sections 4 and 5 to test the merits of two image formation hypotheses.

1. According to experiments performed in 1978 over a five-day period (120 hours) by about 26 researchers associated with the Shroud of Turin Research Project (STURP), these images have no pigment, no binder to carry pigment, no clumping of fibers or threads, no stiffening of the cloth, no cracking along fold lines, no brush strokes, and no outline.
2. STURP concluded the images were also not caused by a scorch from a hot object, any liquid, or by a photographic process.
3. There is a smooth gradation of discoloration on the Shroud from points vertically closer to the body relative to points vertically further from the body.
4. STURP detected no body decay products on the cloth.
5. The images are formed by some of the flax fibers in the linen threads being discolored.
6. The Shroud contains full size front and dorsal (back) images of a man who was scourged and crucified exactly like Jesus was scourged and crucified according to the New Testament.
7. The image of the face is a normal width for a human face.
8. The front image is a vertical projection upward from the body. The back image is a vertical projection downward from the body.
9. The Shroud does not include images of the sides of the body or the top of the head.
10. The front and dorsal images have a good resolution, perhaps in the few mm range.
11. Based on the location of the blood on the Shroud, the front and dorsal images are on the side of the cloth that faced the body. There appears to be very dim indications of the face and the hands on the other side of the cloth, i.e., on the outside of the wrapped configuration, though this is disputed.
12. A typical linen thread contains a hundred or more flax fibers twisted together. The images on the Shroud are caused by fiber discoloration in only the top two or three layers of fibers in a thread, with those discolored fibers facing toward the body, on both the front as well as the dorsal image.
13. The threads in the images are discolored in a mottled pattern, yet this mottled pattern forms the front and dorsal images of a crucified man.
14. The density of ion tracks in the image fibers is about the same as the density of ion tracks in the non-image fibers.
15. The discoloration on all the discolored fibers has approximately the same color, usually called a straw-yellow or light sepia color.

16. A flax fiber has a diameter of about 15 microns or micrometers ( $\mu\text{m}$  = one millionth of a meter), which is about one-fifth the diameter of a human hair. The discoloration on an image fiber has a thickness of less than  $0.2 \mu\text{m}$ , with the discoloration around the outer circumference of the fiber, with the inside of the flax fiber not discolored. Thus, in this example of a flax fiber with a  $15 \mu\text{m}$  diameter, the inside  $14.6 \mu\text{m}$  of the fiber diameter would not be discolored.
17. Images can be seen on the Shroud that result from bones near the surface of the body. This includes the area of the teeth, hands, backbone, and possibly the skull.
18. The images are two-dimensional yet contain 3D or topographical information related to the vertical distance from the body to the cloth at each point.
19. The images are negative images, i.e. having light and dark areas reversed.
20. The front and dorsal images have about the same quality, as though they were both made by the same process.
21. The discoloration on the image fibers is due to some of the single electron bonds of the carbon atoms being changed to double electron bonds. This is evidently the result of an oxidation-dehydration process.
22. The Shroud of Turin Research Project (STURP) concluded that the discoloration on the fibers is not caused by any material being added to the fibers.
23. The top threads facing the body create a non-discolored region on otherwise discolored threads that are beneath them, like a “shadow” of the top thread on the under thread.
24. The mustache has multiple lights spots or dark spots, depending on whether the observer is looking at either a positive or negative image.
25. The images were not affected by heat in the 1532 fire or by subsequent water thrown onto the Shroud after the fire.
26. Images of various parts of flowers were probably encoded onto the side of the Shroud facing the body, as though flowers were placed between the section of the cloth that was below the body and the section of the cloth above the body.
27. During the STURP experiments in 1978, many oxidizing and reducing agents were applied to image fibers to determine which agents would eliminate the fiber discoloration. None of them eliminated the discoloration except for diimite which eliminated the discoloration immediately when it was applied.

### 3. Criteria for Judging an Image Formation Hypothesis

The criteria for judging hypotheses for image formation can be separated into three categories: 1) “it must”, 2) “it should”, and 3) “it is preferred”.

(3.1) For a hypothesis to be true, it must be consistent with all the evidence that is believed to be true. If a hypothesis contradicts any evidence known to be true, then the hypothesis cannot be true. A hypothesis that is consistent with all the evidence may be true but is not necessarily true. If a hypothesis claims to be consistent with only a few of the evidences, but makes no claim about being consistent with the remainder of the evidences, then initially it is probably less credible than a hypothesis that claims to be consistent with more of the evidences, even if it also

makes no claim about the remainder of the evidences. The VCRB hypothesis (Ref. 2) claims to be consistent with the 27 evidences from which it is derived. While a hypothesis must be consistent with all the evidence to be true, it usually gains sufficient credibility to be considered true based on its predictions. If a hypothesis makes no predictions, then how can it gain sufficient credibility to be considered true?

(3.2) A hypothesis should make predictions that are testable and falsifiable. If a prediction is tested and found to be true, then the hypothesis gains in credibility, though it may not yet be considered as proven to be true. It may take multiple predictions to be tested and proven to be true before the hypothesis is considered by the majority of researchers to be true beyond a reasonable doubt. If a prediction is tested and found to be false, then the hypothesis is proven to be false, at least as stated. It is important that a prediction be falsifiable, i.e. capable of being proven false when tested. A prediction that cannot be proven false when tested is of questionable benefit if proven to be true. A unique prediction is a prediction that no other hypothesis makes. For example, the VCRB hypothesis makes a unique prediction about the distribution of the carbon dating across the Shroud. If a unique prediction is tested and found to be true, then it can significantly add to the credibility of the hypothesis. Depending on the nature of the unique prediction, if proven to be true when tested, it may add sufficient credibility to the hypothesis that many would consider the hypothesis to be proven true.

(3.3) Six items can be considered in the “it is preferred” category.

(3.3a) It is preferred that a hypothesis explains more than one mystery of the Shroud. Scientists usually consider a hypothesis to be more attractive if it explains multiple aspects of a phenomenon, though this alone would not prove the hypothesis to be true. For example, the VCRB hypothesis proposes explanations for the image formation, the 1988 carbon dating of the Shroud, and possibly why the blood that would have dried on the cloth is now on the Shroud, since dried blood does not normally absorb into cloth. Further consideration should be given to whether other hypotheses for image formation attempt to explain other mysteries of the Shroud.

(3.3b) It is preferred that a hypothesis is simple rather than complex. Scientists prefer to deal with a hypothesis that is simple rather than complex because it is easier and is sometimes assumed to be more likely true. However, a hypothesis should not be rejected based on its complexity because reality can be complex. For example, the VCRB hypothesis is relatively complex but its complexity results from the complexity of the evidence. This preference for simplicity is often called “Occam’s razor” when phrased as a preference for as few assumptions as possible, though it is often difficult to count the number of assumptions because of how they can be interrelated. This preference for simplicity is a useful tool when dealing with multiple hypotheses that otherwise have equal merit in that they are consistent with all the evidence and have made predictions that have proven to be true. While this preference for simplicity should not be used to reject a hypothesis, because reality can be complex, it can be used to focus research effort on one hypothesis rather than others.

(3.3c) It is preferred that a hypothesis exhibits beauty. Beauty in science or mathematics is something that researchers can find attractive, but it can be difficult to describe because beauty is often “in the eye of the beholder”. For example, beauty in a hypothesis can be related to

symmetries, similarity of patterns, relations of the more complex to the simpler, familiarity with the form of the equations, the way in which the equations can be simplified, etc. Recognition of this beauty can cause a feeling of joy and satisfaction in the researcher. As with criteria 3.3b, this preference for beauty should not be used to reject a hypothesis but can be used to focus research effort on one hypothesis rather than others.

(3.3d) It is preferred that a hypothesis considers aspects of the Shroud that it does not explain. Examples include: 1) the normal width of the face on the front image appears to indicate that when the front image was encoded, the cloth was essentially flat above the head rather than wrapped around it, and 2) the lack of flattening of the buttocks and back on the dorsal image appears to indicate that when the dorsal image was encoded, the body was above the dorsal half of the cloth. Thus, when the images were encoded, the body appears as if it was located above the cloth that was below it, and that the cloth above the body was essentially flat and at least a small distance above the body. A good explanation for these features has not been documented, and the VCRB hypothesis in Ref. 2 does not propose an explanation. However, since the electromagnetic force is so much stronger than the gravitational force, since like electrical charges such as two protons will repel each other, and since the VCRB hypothesis involves electrical charge distributions, these considerations suggest that these features of a levitated body and a levitated top cloth might be explained by the repulsive forces resulting from the bottom cloth, the body, and the top cloth all having a net electrical charge such as a net positive charge. But the VCRB hypothesis does not explain how these electrical charge differences could have come about.

(3.3e) It is preferred that a hypothesis is corroborated by one or more diverse areas of study. For example, the VCRB hypothesis is corroborated by two diverse areas of study: 1) there is a good correlation between the predicted distribution of neutron absorption on the Shroud (Ref. 6) and Tom McAvoy's study of the distribution of the fluorescence on the Shroud (Ref. 7 and 8), and 2) the conclusion of the VCRB hypothesis that the discoloration on the fibers that caused the images was caused by a high frequency vertical oscillation of the nuclei in the body could be the mechanism by which Jesus' body transitioned to an alternate dimensionality, as concluded in Biblical and scientific studies of how Jesus' body disappeared in his resurrection (Ref. 9 and 10).

(3.3f) It is preferred that a hypothesis clearly explain how information was used to form the images on the Shroud. Every image that can be seen is due to information controlling the image formation process. For example, information is needed to control the sequence of letters and the grammar in a book or magazine, and information is needed to control the pattern of pixels that form the letters in a book or magazine. Information is needed to control the pattern of pixels in any image that can be seen including in a photograph, magazine, television, or computer monitor. This also applies to the Shroud of Turin. On the Shroud, information is needed to control the pattern of the discolored fibers that are in the front and dorsal images, both their location and length. Thus, a document that proposes an image formation hypothesis should clearly discuss the specifics regarding the information that controlled the discoloration on the fibers, since it is the discoloration on the fibers that forms the images. For example, where did the information come from, how was the information transported to the cloth, how was the information deposited on the cloth, and how was the information involved in discoloring the fibers? The VCRB hypothesis (Ref. 2) proposes that the information required to form the images

was communicated from the body to the cloth by radiation emitted in the body, was deposited on the cloth when the radiation was absorbed by the cloth, and the fibers were discolored by the energy in this radiation.

#### 4. Application to a Generic Scorch Hypothesis

The 27 evidences in Section 2 were used to determine whether a generic scorch hypothesis for image formation would be consistent with the evidence. This generic scorch hypothesis was assumed to involve placement of a linen cloth around a hot object such as a statue or a bas relief. Contradictions between this hypothesis and the evidence are listed below.

1. STURP concluded the images were not caused by a scorch from a hot object. This is because the images did not fluoresce under ultra-violet light. This conclusion directly contradicts the scorch hypothesis.
2. There is a smooth gradation of discoloration on the Shroud from points vertically closer to the body compared to points vertically further from the body. This is not consistent with contact between the Shroud and a hot object as in a scorch hypothesis. At each point, there is either contact or no contact. This is basically inconsistent with a smooth gradation of discoloration.
3. The image of the face is a normal width for a human face. If the Shroud were draped around the face on a hot statue, the face on the Shroud would be much wider than a normal face.
4. The Shroud does not include images of the sides of the body or the top of the head. A statue hot enough to scorch the front and dorsal images would probably also form side images.
5. A scorch would quickly go through the thickness of the cloth, so there would be an easily discernable image on both sides of the cloth. This is contrary to the Shroud.
6. The images on the Shroud are caused by fiber discoloration in only the top two or three layers of fibers in a thread. A scorch, as assumed here, would discolor all the fibers in a thread.
7. The threads in the images are discolored in a mottled pattern. This mottled pattern that is on the Shroud would not be produced by a scorch.
8. The discoloration on an image fiber has a thickness of less than 0.2  $\mu\text{m}$ , with the discoloration around the outer circumference of the fiber, with the inside of the flax fiber not discolored. This would not be true of a scorch.
9. Images can be seen on the Shroud that result from bones near the surface of the body. This includes the area of the teeth, hands, backbone, and possibly the skull. This is not true of a scorch.
10. The images on the Shroud contain 3D or topographical information related to the vertical distance from the body to the cloth at each point. This is not true for a scorch on a cloth laid around a hot object.
11. In the images on the Shroud, the top threads facing the body create a non-discolored region on otherwise discolored threads that are beneath them, like a “shadow” of the top thread on the under thread. This would not be true of a scorch because of how rapidly the heat would be transferred across the thickness of the cloth.
12. On the Shroud, there are multiple bright or dark spots on the mustache, depending on whether the observer is looking at a positive or negative image. This is not explained by a scorch.

Also, it is not known whether specific scorch hypotheses make predictions. There are different types of scorch hypotheses that may not contradict the evidence as above. However, they are also expected to contradict the evidence in multiple ways. If a hypothesis contradicts the evidence in any way, it cannot be true.

## 5. Application to the Roasted Flour& Oil Hypothesis

As another example, the 27 evidences in Section 2 will be used to judge the merits of Colin Berry's Roasted Flour and Oil (RFO) hypothesis for image formation (Ref. 5, posted June 20, 2020). He calls this his FILM-SET model, which is an acronym for Flour Imprint, Liquid-Migrating, Solid-Entrapping Threads. He previously called this his "Model 10" hypothesis. In a review of Berry's postings in Ref. 5 over a 12-year period, it was difficult to determine the nature of his RFO hypothesis. His hypothesis appears to be that a mixture of flour and oil was placed on a human-size statue or bas relief of a crucified man. It was then roasted over a linen cloth to produce the images of a crucified man that is on the Shroud of Turin. He has tried to optimize his hypothesis in multiple ways, finally using a mixture of flour and oil on a small toy figurine of the super-hero called Iron Man. He then placed this flour and oil covered figurine on a piece of linen cloth and roasted it in a hot oven to produce an image of the figurine on the cloth. The figurine has a height of about fifteen cm (5.9 inches) and appears to be plastic. My comments are below.

1. Berry evidently assumed that the Shroud was proven to be some type of a forgery or fake because of the 1988 carbon date to 1260 to 1390, but multiple analyses have proven that this date for the Shroud should be given no credibility (Ref. 6). According to this assumption, the RFO process to make the images on the Shroud probably took place between 1260 and 1390, but this ignores the many evidences that the Shroud is much older than 1260-1390. If the Shroud was made in 1260-1390, then the nail wounds would have been in the middle of the palms instead of the wrists, and the thumbs would have been prominently shown, consistent with paintings in the middle-ages but inconsistent with the Shroud of Turin.
2. The RFO process to make the images probably would have left material on the cloth that would have been detected during the five days of STURP experiments in 1978. It probably would have produced clumping of fibers or threads and possibly stiffening of the cloth.
3. The STURP experiments found no evidence of capillarity (soaking up of a liquid) because only the top two or three layers of fibers were discolored, yet the RFO process would have involved capillarity in the fibers and threads due to soaking up of the oil.
4. The RFO hypothesis does not explain the scourge marks or blood stains on the Shroud.
5. The Shroud includes front and dorsal images of a crucified man. The quality of both images was about the same, indicating that both images were probably formed by the same process. However, Berry's testing related to his RFO hypothesis only produced an image of the bottom side of the figurine that was lying on the cloth. We are not shown evidence of an image that was produced on cloth that was above the figurine.
6. The resolution of the front and dorsal images on the Shroud has been estimated to be about four to five mm. It appears that the resolution of the toy figurine produced on the cloth is not as good as the images on the Shroud. This would have been far more apparent if testing of

the RFO hypothesis used a larger model of the crucified man that is imaged on the Shroud rather than a toy figurine.

7. The plastic figurine used for testing of the RFO hypothesis produced a blurry erratic image of itself on the side of the cloth that was in contact with the bottom of the figurine. We are not told or shown whether there is also an image on the other side of the cloth. If there is an easily discernable image on the other side of the cloth, this would contradict the Shroud of Turin. We are also not shown an image on a cloth that should have been placed above the figurine during the roasting process.
8. The images on the Shroud are caused by fiber discoloration in only the top two or three layers of fibers in a thread, with those discolored fibers facing toward the body, on both the front as well as the dorsal image. This is referred to as the superficiality of the images on the Shroud. It appears there is no claim that this is true for the RFO hypothesis, and it is doubtful that this would be true.
9. The threads in the images on the Shroud are discolored in a mottled pattern, yet this mottled pattern forms the front and dorsal images of the crucified man that can be seen on the Shroud. It is difficult to imagine how a scorch would produce the mottled pattern that is on the Shroud.
10. The discoloration on all the discolored fibers on the Shroud has approximately the same color, usually called a straw-yellow or light sepia color. The image of the figurine on the cloth is the wrong color. It might be called a gray to black color.
11. The discoloration on an image fiber on the Shroud has a thickness of less than 0.2 micrometers ( $\mu\text{m}$ ), with the discoloration around the outer circumference of the fiber, with the inside of the flax fiber not discolored. Apparently there is no claim that this is true for the RFO hypothesis, and it provides no mechanism that would cause this to be true.
12. Images can be seen on the Shroud that result from bones near the surface of the body. This includes the area of the teeth, hands, backbone, and possibly the skull. The RFO hypothesis provides no mechanism that would cause this to be true.
13. The images on the Shroud contain 3D or topographical information related to the vertical distance from the body to the cloth at each point. The RFO process may indicate some slight presence of 3D information on the cloth but it appears to be less significant than on the Shroud. There is also no clear mechanism in the RFO hypothesis that would produce 3D information on the cloth.
14. On the Shroud, the discoloration on the image fibers is due to some of the single electron bonds of the carbon atoms that were previously in the cellulose being changed to double electron bonds, apparently due to an oxidation dehydration process. This means that there were no materials added to the cloth to form the images. Instead, the atomic structure of the atoms in the cellulose was merely rearranged, with addition of oxygen and removal of water in the process. This is contrary to the RFO hypothesis which claims that a chemical reaction of flour and oil on the cloth in the roasting process caused the discoloration.
15. On the Shroud, the top threads facing the body create a non-discolored region on otherwise discolored threads that are beneath them, like a “shadow” of the top thread on the under thread. It appears there is no claim that this is true for the RFO hypothesis, and it is very unlikely to be true due to the capillarity of the oil on the cloth.
16. On the Shroud, there are multiple bright or dark spots on the mustache, depending on whether the observer is looking at a positive or negative image. It appears the RFO hypothesis does not explain these spots on the mustache on the Shroud.



17. The images on the Shroud were not affected by heat in the 1532 fire or by subsequent water thrown onto the Shroud after the fire. It appears the RFO hypothesis does not explain this.
18. Images of various parts of flowers appear to have been encoded on the side of the Shroud facing the body. It appears the RFO hypothesis does not explain this.
19. During the STURP experiments on the Shroud in 1978, many oxidizing and reducing agents were applied to image fibers to determine which agents would eliminate the fiber discoloration. None of them eliminated the discoloration except for diimide which eliminated the discoloration immediately when it was applied. It appears the RFO hypothesis does not explain this.

Also, it is not known whether the RFO hypothesis makes any predictions.

## 6. References

1. C. Donnet, et al., “2D Reproduction of the Face on the Turin Shroud by Infrared Femtosecond Pulse Laser Processing”, *Applied Optics*, March 20, 2019
2. Robert A. Rucker, “Hypothesis for Image Formation on the Shroud of Turin”, revised January 19, 2024, paper 34 on the research page of [www.shroudresearch.net](http://www.shroudresearch.net)
3. Giulio Fanti, et al., “Evidences for Testing Hypotheses about the Body Image Formation of the Turin Shroud”, Sept. 8-11, 2005
4. Giulio Fanti, “Hypotheses Regarding the Formation of the Body Image on the Turin Shroud. A Critical Compendium”, 2011
5. <https://shroudofturinwithoutallthehype.wordpress.com/2020/06/20/shroud-of-turin-final-report-of-my-8-year-learning-curve-entirely-consistent-with-my-final-flour-imprinting-model-10-crucial-second-stage-roasting-of-a-medieval-body-contact-imprint-to-mimic/>
6. Robert A. Rucker, “Solving the Carbon Dating Problem for the Shroud of Turin”, revised October 28, 2023, paper 33 on the research page of [www.shroudresearch.net](http://www.shroudresearch.net)
7. Thomas McAvoy, “On Radiocarbon Dating of the Shroud of Turin”, [www.researchgate.net](http://www.researchgate.net)
8. Thomas McAvoy, “Shroud of Turin ultraviolet light images: color and information content”, *Applied Optics*, Vol. 60, No.22, August 1, 2021
9. Robert A. Rucker, “The Disappearance of Jesus’ Body, Part 1: Biblical and Theological Considerations”, October 8, 2016, paper 1 on the research page of [www.shroudresearch.net](http://www.shroudresearch.net)
10. Robert A. Rucker, “The Disappearance of Jesus’ Body, Part 2: Physical Considerations”, October 11, 2016, paper 2 on the research page of [www.shroudresearch.net](http://www.shroudresearch.net)