Comments On the Book
"The Resurrection of the Shroud"
by Mark Antonacci

As a scientist and one of the members of STURP who went to Turin in 1978, I found The Resurrection of the Shroud by Mark Antonacci (M. Evans and Co., Inc. New York, NY, 2000) to be one of the most remarkable books I have read on the subject. I should state that my perspective is primarily that of a scientist, and I will not review some aspects of studies on the Shroud that are mentioned in the book and are favorites of other workers. I will confine my comments to an analysis of the book's "science" vis-à-vis STURP's scientific observations and the generally accepted laws of chemistry and physics.

Descriptions and reports of studies and beliefs involving the Shroud are massively researched and well written. The book is the best recent compilation of "theories" on image formation that I have seen. There are photographs and details on attempts that have been made to reproduce the appearance of the image in both Europe and the United States, and it discusses the known and speculated history of the Shroud concisely and in detail. It gives inside details of the squabbles among researchers and the conflicts among observations that I had not seen; however, I believe that the "science" part is indefensible.

The author states the following: "For the first time in history, the worldwide public has an unprecedented opportunity to look at the question of the occurrence of the crucifixion and resurrection of the historical Jesus Christ in an impartial, comprehensive manner." His book is an attempt to *prove* the resurrection through science. This fact makes a detailed analysis of his "science" imperative.

Perhaps the best introduction to the "science" found in the book are the author's own words: (p. 245), "Despite centuries of efforts from people across the earth, all proposed mechanisms for creating the image on the Shroud have failed to account for the unprecedented characteristics of the body images and blood marks until the recent development of the Historically Consistent Method [the heart of the book] that was developed by combining research from scientists throughout the world on all aspects of the body images and blood marks on the Shroud. *This theory states that if a body instantaneously dematerialized or disappeared, particle radiation would be given off naturally and all the unique features found on the Shroud's body images and blood marks would occur.* As detailed in Chapter 10, this method accounts for all of the Shroud's body image features …" And on p 246, "The particle radiation, consisting of the basic building blocks of matter, contains a neutron flux, which creates additional C-14 throughout the cloth." "*For either* [ionizing particles or neutrons] *to have irradiated the Shroud from a corpse would have been an unprecedented event that could only be explained by the resurrection."* [Emphasis added.]

An honest review of the author's claims in terms of rigorous Scientific Method requires that each part of his system be stated as clearly as possible. Each part must then be tested with equal vigor and objectivity against published descriptions of the Shroud and known physical and chemical principles.

Unfortunately, some statements are made in the book that were not adequately researched. For example, on p. 6 the author reports the things STURP proved were *not* the case. The source of this information is not clear, but two of the items were not part of the STURP consensus: 1) "It was not made by any natural means of draping a cloth over a human body," and 2) "It was not a scorch." There is no "scientific" proof for either of those statements.

We could not rule out all possible "natural" mechanisms for image formation or all possible ways the cloth could have been draped or been bound to the body. And, very definitely, the primary chemical composition of the color of the image is the same as that from a scorch. That certainly does not rule out all possible scorch or heating mechanisms.

It is also said (p. 30), "--- the bloodstains could not have been encoded on the Shroud simply by direct contact between a bloody body and a linen cloth surrounding it." And on p. 225: "These unique blood marks have never been displayed so realistically on cloth, canvas, or any other surface; they appear on the cloth exactly as they would appear on a real human being with extensive wounds." And: "No scientists, physicians, artists, or others have ever been able to convey such anatomically precise and complete blood marks onto cloth by direct contact or by any means, or portray them on any kind of surface."

The history of science is full of phenomena that seemed incomprehensible but were later explained by observations and measurements. Failure of experiments proves little without absolute control over experimental conditions. Such negative evidence should not be used to test scientific hypotheses. Even positive results with experiments in science need to be confirmed, preferably by independent investigators.

Although the author repeatedly referenced Dr. Robert Bucklin, a forensic pathologist who worked with STURP, he did not mention Bucklin's discussions on mechanisms for transferring blood stains to cloth. Indeed, the following statement is made by STURP members in a refereed scientific article (Jumper, Adler, Jackson, Pellicori, Heller, and Druzik, ACS Advances in Chemistry No. 205, Archaeological Chemistry III, Joseph B. Lambert, Ed., Copyright 1984), "First, the blood images present no mystery; all evidence suggests that the blood went on as one would expect for a cloth in contact with wounds or the normal secretions of such wounds. We therefore suggest that the blood images are the natural consequences of the linen being in contact with wounds."

Bucklin discussed the properties of blood in detail, and his information has been confirmed by discussions with other experienced forensic pathologists. Blood transfers from a body to a cloth are extremely common, and they provide one piece of the forensic

evidence used to estimate the time between wounding and death. When you cut yourself and bleed, there is an initial adherence of platelets to the margin of the wound. Fibrin then crosslinks to form a stronger clot. An enzyme, Plasmin, can reliquefy the clot after some time, allowing it to flow again. This is why you see a pretty good representation of the cut on your finger on the pad of a Band-Aid. However; if the person is dead when blood flows, the flow "congeals." This is not the same process as observed with a living subject. The gel can and does transfer to other surfaces (usually clothing), giving a fair representation of the wound. And it is common to see blood serum flowing faster than the blood cells through the cloth, just as observed on the Shroud. The proteins in serum are of much lower molecular weight than some other products and the blood cells. This is very similar to a process we use in analytical chemistry to separate materials according to molecular weight. This information was generally known before the trip to Turin, and it should have been considered in developing a "consistent" method.

SCIENTIFIC METHOD:
Real science requires the rigorous application of Classical Scientific Method. Each phase of Scientific Method has its critical components and difficulties. Some critical components are discussed below.

Identify and clearly state the goal:
When we were testing our equipment before the Turin trip, a minister in Amston, CT, told me, "I'm so glad you are going to prove the resurrection of Jesus." That was his goal. Recognizing the goal is an important, and sometimes difficult, part of science.

The goals of the different studies on the Shroud are not always clearly stated in writings on the subject, and goals were never agreed upon by all of the STURP scientists. Some would say that we were going to test the "authenticity" of the Shroud, but the word can be interpreted in many ways. There is a huge difference among the following (not comprehensive) list of possible goals: 1) test whether the image was a hoax that used known methods for producing an image; 2) estimate the probability that the Shroud is an "authentic" shroud; 3) prove that the Shroud was the Shroud of Jesus; and 4) test whether the Shroud proved the resurrection of Jesus. Nothing is simple, and definitions become critical in the performance of a scientific study.

Assemble all pertinent data:
At the beginning of the STURP planning stage, we had very little scientific data to use as a basis, and many of the prior observations were in conflict. The author makes heavy use of tests run by early investigators (e.g., Dr. Paul Vignon, 1900-1943, and Dr. Pierre Barbet, 1932-1961) who largely tried to reproduce the appearance of the Shroud before the 1978 observations were made.

"Assemble all pertinent data" means that you must include all reproducible, controlled measurements, whether you like them or not, when you are testing hypotheses. Data are "pertinent," if they can be supported with evidence. It is perfectly valid to use tentative results in developing hypotheses for testing, but *all of the hypotheses must be tested*.

Data assembly is where people who are defending a position do their best work. The persons who devoutly hoped to prove the Shroud was a hoax tended to hide or rationalize some of the observational facts. The "true believers" can take a single fact and use it to build a gigantic superstructure of speculation. The most damaging things a "scientist" can do at this stage in the development of a "scientific" study is to include speculations on an equal basis with tested facts and exclude observations he does not like.

Hypothesize and innovate:
The word "theory" is usually applied incorrectly to questions that involve science in most popular literature. An unproved statement that is intended for study and testing is called an "hypothesis." The Method of Multiple Working Hypotheses encourages a scientist to state as many credible explanations for an observation as possible and then *test them all equally against the same observations.* Too often I see a speculation proposed and supported by reference to very selected "facts" or other speculations without looking for any equivalent testable phenomena that could have made the same effect.

It is perfectly valid (but absurd) for me to state, "Hypothesis: the Shroud was painted by elves in the Black Forest." But I must not publish it as a "theory" before it has been tested and at least partially confirmed.

Test and confirm:
The rigorous application of Scientific Method requires that all of the hypotheses that are proposed be tested equally. Hypotheses that involve miracles can not be rejected categorically, but they are impossible to test experimentally.

As new methods and/or information become available, old hypotheses should be retested. Measurements are critical, and the methods used to measure a phenomenon must be carefully calibrated. All experimental methods must be published in detail for a publication to achieve the right to be called "scientific." Science deals in numbers. The author appears to have selected older observations that fit his goal better than some newer ones.

Some people say science is no good, because the statements are always changing. The author states that "science is not absolute." That is the way science should work: It is self-correcting. That is why the latest tested and confirmed evidence should be used in the justification of a theory.

After weak hypotheses have been eliminated according to known facts, you hope that at least one remains. Sometimes you can't find a viable hypothesis. That is where we stand with regard to image-formation hypotheses. Some have not yet been tested, something is wrong with all of the published ones, and some are impossible to test.

Most scientists who are left with no hypothesis other than one involving a miracle, which they can neither prove nor disprove, will start looking for more hypotheses. Some prefer to accept a miracle. We have seen both approaches with the Shroud.

Hypotheses do not become "scientific theories" without rigorous testing. Image-formation needs much more work. The Resurrection of the Shroud illustrates but does not solve the problems.

The STURP project allowed more testable hypotheses to be proposed after the study than we had before. We amassed considerable evidence that the image was not a "painting" in the normal sense of the word; however, it was not possible to test all conceivable ways an image could be hoaxed or appear as a result of natural processes.

You can judge the strength of an hypothesis by how many careful and accurate observations fit the hypothesis. Then all ethical scientists apply Occam's razor. It is a logical principle attributed to William Of Occam, and it is often called the principle of parsimony. Since the Middle Ages, it has played an important role in eliminating fictitious or unnecessary elements from explanations. We usually state it as, "The hypothesis that includes the smallest number of special assumptions has the highest probability of being closest to the truth." Many "theories" I have seen proposed about the Shroud can not pass Occam's Razor unscathed.

When I applied Occam's Razor to the "theories" on the image and dating that were reported in The Resurrection of the Shroud, I got the following series of assumptions. Many were not overtly stated in testable terms in the book. All of these assumptions are required to enable the "theory" that the author calls his "Historically Consistent Method."

1) Assume that the cloth was not bound to the body (required for assumptions on the blood stains and image).

2) Assume that the body dematerialized (accepted by the author and attributed to John Jackson).

3) Assume that the process that produced the image was very fast (milliseconds were mentioned).

4) Assume that the energetics of the dematerialization did not destroy the material of the cloth or the blood on the body. (This is required, because energy is transferred in chemical and physical processes. Sufficient energy would have destroyed the Shroud, including the blood stains.)

5) Assume that the mass of the body was not converted quantitatively into energy. (One of the author's sources assumed dematerialization into energetic photons. It is unclear how much energy the author assumes. Complete conversion of the mass of a normal human body into energy would have had the effect of a huge H bomb, on the order of 200-300 megatons of TNT.)

6) Lacking the assumption of dematerialization into pure energy, you must make other assumptions to explain the disappearance of the body and the appearance of the correct amount and kind of radiation needed for the author's image-formation

"theory." (The author seems to accept disappearance of the body down a wormhole.)

7) Assume that photons (such as gamma rays) of sufficient energy and number were produced at the instant of dematerialization to enable some nuclear transformations. (This is required in order to provide a method for the production of energetic protons that are required for his image-formation "theory" and neutrons that would make the ^{14}C date incorrect.)

8) Assume that this insubstantial volume, originally occupied by the body, did not expand like a heated gas or disappear into a black hole but retained its original geometry long enough for the cloth to fall all of the way through. (This is required to enable his statements about the accuracy of image production.)

9) Assume that sufficient energy was deposited in the products of the dematerialization to yield a significant flux of ionizing and non-ionizing radiation. (He needs non-ionizing radiation to support his "theory" on the preservation of the cloth.).

10) Assume that blood stains are faithfully represented on the cloth as a result of its passage through the volume previously occupied by the body. (He states that no other mechanism can explain their appearance.)

11) Assume that energetic protons interacted with the cloth, did not significantly penetrate the cloth, and ultimately produced the color.

12) Assume that the energy had a perfectly homogeneous composition and intensity over the entire extent of the body and cloth such that image density can be related directly to contours, shapes, and characteristics of the body.

13) Assume that the blood on the body (and, incidentally, the material of the Shroud) does not undergo the same dematerialization as the body.

14) Assume that the ionizing radiation that changed the chemical composition of the cloth did not illuminate the entire surface of the cloth, interacting only with the highest parts of the weave near the body. (This is required to agree with STURP observations on the distribution of the image color on the cloth.)

15) Assume that nuclear reactions between energetic particles and/or photons from the body and components of the cloth produced a significant population of new ^{14}C atoms. (This is proposed to explain the Medieval date for the Shroud that was measured in 1988.)

16) Assume that secondary images (e.g., coins and flowers) can be seen that help prove the resurrection.

The list shows several series assumptions, where one assumption depends on another.

The Resurrection of the Shroud does not make comprehensive tests of its "theories" as would be done according to Scientific Method. It is not the kind of publication you would see in peer-reviewed scientific literature.

A brief description of how the 1978 study of the Shroud was planned should help illustrate Scientific Method. Each member of STURP who had the responsibility for a section of the study made the same kind of study before the trip to Turin. I am reporting only subjects that are very familiar to me as an illustration of one step in Scientific Method.

Before we went to Turin, I made a number of predictions regarding chemical entities that might be expected to be on the cloth and how to observe them (Proceedings of the 1977 United States Conference of Research on The Shroud of Turin, March 23-24, 1977, Albuquerque, NM, USA).. The main focus was on the claim made by Bishop Pierre d'Arcis of Troyes that the image on the Shroud was painted. Note that the hypotheses were framed before we saw the Shroud. A very large part of the work done with STURP was done before we saw the Shroud. Our goal was to gather observations and measurements that could be used to test all of our starting hypotheses and any new ones.

Previous publications gave us very little to go on, and the photographs did not show enough detail; therefore, we made literature searches for the properties of all possible materials we might be able to identify on the Shroud.

We searched the literature for all historical reports on methods of producing linen at different times through history. Pliny had a description of linen production during Roman times (see Book 19 §48), and it was very useful. We also talked with every textile historian we could find. For example, while we were in Turin, we talked with Anna Maria Donadoni Roversi. She could describe in great detail the technology used to produce linen from Egyptian times to the present, and she loaned us invaluable linen samples of known age and provenance. Such information enabled us to plan observational methods for finding traces of materials that might suggest a source for the linen.

Because the Shroud had been said to be a painting, we searched painting pigments, media, and vehicles, known color-producing reactions of linen, etc. For example, Tyrian Purple (6,6'-dibromoindigo) had been used to represent blood. We made a comprehensive list of all pigments and media used before Medieval times.

The earlier investigators had reported a "grainy" structure in the image. That sounded like a mordant had been used, and the color would agree with the ancient practice of using a mordant with alizarin (Madder root). We would test for it.

Pliny mentioned struthium, and we found it was Saponaria officinalis. I spent many hours at the library tracking down all of the chemical components of Saponaria. Several specific components could be used to test the cloth.

We did the same kind of literature search for aloes, frankincense, and myrrh. Aloes contains aloe-emodin, a fused-ring compound that has two equivalent structures, and it turns pink in ammonia. Aloe-emodin anthranol shows green fluorescence. Myrrh is a complex mixture with a thick oily fraction (cuminol, eugenol, metacresol, pinene, limonene, dipentene, and two sesquiterpenes that are responsible for the odor), a resin fraction composed of mixed resin acids (e.g., $a-, b-, g-$ commiphoric acids), some residues that yield protocatechuic acid and pyrocatechol (easy to check for), and a lot of a gum that resembles acacia gum. Such gums contain some relatively unusual sugar units that can be sought.

We stated hypotheses for each possible material that could be on the Shroud, and we tested for them by using standard, published and tested "scientific" analytical methods.

The preservation of the cloth is mentioned as an anomaly in the book. The fact is used as a basis for speculation. It is claimed that neutrons will strengthen cloth, allowing the claim to be made that the excellent condition of the Shroud proves that radiation was involved. No alternative hypotheses were sought or mentioned, illustrating very weak and/or goal-directed "science."

Just one of many possible alternate hypothesis for the preservation of the cloth that can be tested is that the cloth was washed with Saponaria officinalis when it was produced. Pliny mentioned this, and textile experts are familiar with this use of the plant. A conservator at the Museum of Egyptology in Turin had used Saponaria to clean and preserve museum specimens. The author did not search for alternate hypotheses for the presumed abnormal preservation, accepting the assumed preserving effects of radiation at face value to help support his "theory." Incidentally, we ran x-ray fluorescence tests on a First Dynasty sample of linen that was loaned to us by the Museum of Egyptology in Turin: it was deep sepia in color, but it was quite supple and free of mold damage.

STURP personnel made some preliminary tests on this "Saponaria hypothesis." Very little confirmatory evidence was found on the Shroud. The age of the cloth and damage during the fire of 1532 make some chemical testing difficult. More work needs to be done. However several circumstantial bits of evidence that Saponaria might have been present early in the history of the cloth should be mentioned. Saponaria is hemolytic, which could explain why the old blood stains are still red on the Shroud. We found that Saponaria was used in clinical chemistry to hemolyze blood for laboratory analysis. The process releases the hemoglobin. Hemoglobin is quite stable, and an observation of red blood would suggest either painting or hemolysis. Diane Soran (deceased) of Los Alamos tested hemolysis on Saponaria-washed cloth before we went to Turin. The blood stays red. It is still red on those 27-year-old samples. This observation supports an hypothesis that Saponaria was on the cloth at the time of image formation.

Saponaria hydrolyzes to produce some aglycones that are fluorescent, and the non-image part of the Shroud is weakly fluorescent. Unfortunately, we did not have equipment to do a detailed test on the surface of the cloth, and we have not studied how Saponaria fluorescence changes with age. Saponaria is a potent preservative. Kuszlik-Jockym and

Mazur reported that Saponaria glycosides even stopped alcoholic fermentation by yeasts. Hydrolysis releases the Saponaria glycoside sugars. Some of the sugars are pentoses, different from the typical six-membered-ring sugars from starch and cellulose. A few spot tests for pentoses on Raes threads from the Shroud were just above the detection limit for the test, but they did not prove anything conclusive. We could easily detect the pentoses on modern linen that had been made by the ancient process. The Saponaria hypothesis requires fewer "special assumptions" than the radiation hypothesis. We put a significant amount of work into the Saponaria hypothesis, and we certainly would not yet call it a theory. We should still be looking for as many alternate hypotheses as possible and testing them.

The Resurrection of the Shroud relies heavily on papers by Jean-Baptiste Rinaudo that were not published in peer-reviewed literature. Among other things, Rinaudo states that linen is fluorescent. Pure linen is not. He apparently used a white linen of modern manufacture for his tests. Such linen commonly contains "fabric brighteners" to make it look whiter.

On p. 216 it is reported that: "Dr. Rinaudo theorized that, if the body gave off vertically polarized gamma rays from its surface, protons and neutrons would be released from the nuclei of deuterium atoms, uniformly distributed over the body." The author accepts this "protonic theory" as the basis for his image-formation method. It should be heavily questioned.

Rinaudo also assumes that these neutrons produce ^{14}C from ^{14}N and ^{13}C. This "theory" is accepted by the author as an integral part of his "Historically Consistent Method" in order to argue against the 1988 dating of the Shroud. There is no discussion of nuclear cross sections or probabilities of reaction in the book. There is no presentation of real elemental analyses of ancient linens to support the supposition that there was sufficient ^{14}N in the Shroud to account for the assumed increase in ^{14}C. That would have been critical information for a scientific discussion.

The efficiency of nuclear reactions involving neutrons can be extremely sensitive to neutron energies. The cross section, the probability that the $^{14}N + n > {}^{14}C + p$ reaction will occur, is only 1.75 barns with 2,200-meter-per-second neutrons (1 barn equals 10^{-24} cm^2.). In any case, not all reactions with nitrogen produce ^{14}C. The cross section for the ^{13}C n-g reaction that produces ^{14}C is only *0.9 millibarns* ($9 \times 10^{-28} cm^2$). The discussion on enhanced ^{14}C needs a much more thorough treatment.

The assumption of ^{14}C production requires three series "special assumptions": that the body produced gamma rays, that sufficient neutrons were produced from deuterium for a significant nuclear transmutation of nitrogen, and that sufficient nitrogen was present at the instant of the image-forming event. Even more special assumptions are involved to enable atmospheric nitrogen to take part in the process. The chemical kinetics and mechanisms of the reactions required for the incorporation of new ^{14}C into the cloth are not discussed. Insufficient data are presented to support any of the special assumptions, and series assumptions have low probabilities. So many assumptions are involved and

facts are missing from the book's discussion as to make the discussion scientifically useless.

^{14}C normally appears in living organisms as a result of its production at very high altitudes by cosmic rays. It quickly forms $^{14}CO_2$ in the atmosphere and is taken up by photosynthetic plants along with $^{12}CO_2$ and traces of $^{13}CO_2$. That process can not take place in dead plant tissue.

One of the most startling parts of the discussions of "science" in the book appears in footnote 62 on page 310. It states, as follows: "Only a tiny fraction of the atoms are needed to disintegrate to encode the Shroud's images. Possible explanations for the dematerialization of the remaining atoms of the body are discussed below.

"One possible explanation as to what happened to the man in the Shroud under the Historically Consistent or a related method, or to the historical Jesus Christ, was first introduced in a highly respected scientific journal in 1935 by Albert Einstein and Nathan Rosen." This statement is apparently meant to be misleading. The article by Einstein and Rosen had no mention of the Shroud, the body, or anything else directly to do with the "dematerialization" of a body. They discuss only theoretical implications of the Theory of General Relativity. The author is attempting to sound "scientific" while invoking the idea of "wormholes" in space-time.

He continues with, "At this time the science of wormholes is not only mature, but in the words of physicist Matt Visser in Lortenzian Wormholes: From Einstein to Hawking, "…the theoretical analysis of Lortenzian wormholes is 'merely' an extension of known physics --- no new physical principles of fundamentally new physical theories are involved." There is a huge jump between a theoretical concept of wormholes and the disappearance and reappearance of a body.

I sent the author a dissertation on relativity, and I recently received the following statement from him: "All I can say is that the details of space/time travel and wormholes are certainly never going to be known in our lifetimes, if ever, but that experts in the field say that it is possible in the way I discussed it." That does not sound like a "mature" field. The important point is that things that might be possible may be (and in this case are) extremely improbable.

The author is desperately trying to come up with any recognized theory that might suggest a way the body could have disappeared and reappeared in different places at different times. He seems unaware that he is getting himself into more trouble than he is solving.

The theoretical possibility that wormholes might exist on the basis of General Relativity (GR) involves what is called a "singularity" and some very complex mathematics, because GR incorporates gravity into relativity. A singularity is a point of infinite density that causes a catastrophic warp in space-time. A black hole is a singularity, and it tends to eat any materials around it. Black holes have not been observed directly, but

huge gravitational effects can be observed at the cores of galaxies. They also cause the emission of massive amounts of high-energy photons (very short-wavelength light waves) as mass spirals into them. They have some very peculiar properties.

Any wormholes would appear in association with a black hole where not even light can escape. Gravitational forces should completely destroy any object passing through the event horizon of a black hole.

The fact that the Shroud and even the earth are still here would argue against such a speculation. It is also speculated that the body could slip back and forth through a "wormhole" in the vicinity of the singularity, appearing in different places and/or times. Such travel has been considered, and it brings up some very interesting paradoxes. The Michigan State University web page states, "They [wormholes] probably do not exist." The Resurrection of the Shroud has no scientific basis for invoking wormholes in the case of the Shroud.

In "Protonic Model of Image Formation on the Shroud of Turin," Rinaudo claims to have produced "--- a very similar appearance to that of the body image area on the Shroud photographied (sic) by Vernon Miller." The Resurrection of the Shroud accepts this claim and builds on it.

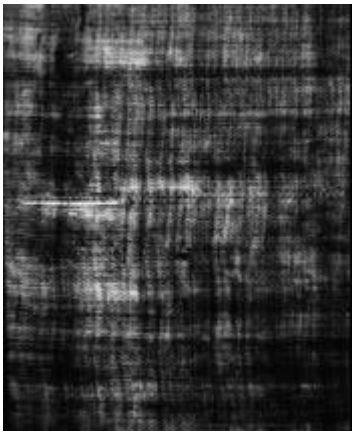
Rinaudo's proton-irradiated samples do not resemble the Shroud image. The outstanding characteristic of the Shroud image is the ***discontinuous*** distribution of the color on the surface. Color appears *only* on the highest parts of the threads in the weave, as can be seen from the excellent photomicrographs taken by Mark Evans of STURP. I would especially recommend ME-029 (above), a 64X magnification of the image area near the nose.

You can easily see specular reflection (a shine) on the parts of the thread that descend to go under the adjoining thread in the weave. STURP members have reported microscopic observations of single fibrils with image color on one end only where it was on top of the thread (Jumper, Adler, Jackson, Pellicori, Heller, and Druzik, ACS Advances in Chemistry No. 205, Archaeological Chemistry III, Joseph B. Lambert, Ed., Copyright 1984). Rinaudo's images clearly show color on all upper surfaces of his samples. His claims were accepted by the author without any apparent attempt to reconcile the appearance with authentic photomicrographs.

I was allowed by the Shroud's Custodian, Msgr. Cottino, gently to probe the Shroud with a dissecting needle under the microscope. I can personally testify to the discontinuous nature of the color and the extremely shallow penetration of the color into the cloth. Rinaudo's samples are entirely different.

It was mentioned that the surface of the cloth without image had a "shine" (specular reflection). During Medieval times, commercial production of linen started, and the linen looks much different than the Shroud. Modern linen has a matte finish as a result of vigorous chlorine bleaching. The technology strongly indicates a very mild bleaching technique in agreement with the methods described by Pliny and in use, with some minor differences, until after the last crusade (AD 1291).

Linen made before the advent of the spinning wheel was spun on a spindle whorl. When the spindle was full, the spinner emptied it by wrapping it around his arm the same as we roll up a long extension cord. Each hank of thread was bleached separately, and each was a little different; indeed, different parts of the same thread show slightly different colors a little like variegated yarn. The warp thread was protected with starch during the weaving process, making the cloth stiff. The final cloth was washed with Saponaria to make it more supple. Medieval linen was spun to great lengths and bleached as the cloth. Most commercial bleaching took place in "bleach fields" in the Low Countries, the genesis for the name "Holland cloth" that is applied to the backing on the Shroud. Considerable material was lost during the bleaching process, and the newer linens are less dense, as can be seen with the Holland cloth. The newer linens are also homogeneous. They do not show bands of different thread in the weave. There is a huge amount of information on cloth technology through time, it is pertinent to studies on the Shroud, and it should have been discussed in the book.



Of greatest interest to me is the fact that the process that formed the image produced slightly different densities of color on the different lots of thread. The photograph is taken from D. H. Janney's image-analysis collection, and it shows the area of the image's face. ***The density of the image is not simply a function of the chemical properties of cellulose. It also depends on the individual properties of the thread, both warp and weft, used to weave each specific part of the cloth.*** We might hypothesize that the

observed effects were caused by differences in the amounts of foreign materials that coated the surfaces of the individual fibrils of the threads as a result of slightly different production techniques.

Al Adler surprisingly reported that the centers of the yellow image fibrils were clear. ***The cellulose core was not affected by the image-producing event.*** Notice that his report concerned the individual fibrils (approximately 13 micrometers in diameter) and not the threads. Adler's observation enables a number of related, testable hypotheses to be formed, and, if confirmed, it would eliminate the author's version of the "protonic theory." In order to color the back side of a fibril or a second, lower layer of fibrils with protons, the proton beam would have to penetrate the upper fibrils through their entire diameter.

NIST has published comprehensive data on the penetration of protons into air and materials of different densities. The protonic "theory" does not agree with known information.

An important component of Scientific Method is *prediction.* Hypotheses that seem to fit all of the data should be capable of predicting the outcome of experiments. We tried many different hypotheses for image formation before going to Turin. None gave a result that agreed with observations. A few additional hypotheses have been developed in later years that should be used to make predictions.

For example, an alternate, testable hypothesis for the color might be that impurities on the surfaces of the fibrils colored more easily than the cellulose of the linen. The color formed by the dehydration (caramelization) of any type of carbohydrate impurity (e.g., starch and/or sugars) would be the result of the same kinds of conjugated structures as produced by cellulose, and *the color would appear on the surface of the fibrils only.* All of the analytical tests described by Heller and Adler would apply to these impurity colors. All colored fibrils should color to approximately the same degree, depending on the amount/thickness of the impurity layer, explaining the "half-tone" effect STURP reported. Slightly different amounts of impurities would be expected on the different hanks of thread used in the weave, explaining the "banded" appearance of the Shroud. There would be little or no contribution from the cellulose in the production of the color. The deposition of an impurity as a result of the starch or washing, might help explain the fact that colored fibrils appear only on the very tops of the top-most threads on the Shroud. Liquids evaporate from the free surface of a cloth, leaving dissolved materials on the top. This effect can be observed with a piece of cloth and a dilute solution of food coloring. The book does not discuss the implications of the banded appearance, and the "protonic theory" would not predict it.

We expected to find starch on the Shroud, so we did not specifically look for it. That was an unfortunate oversight. Starch is a very complex carbohydrate, and not all sources give exactly the same material. The starch might have given us information on is source and the provenance of the cloth.

Starch consists of two main polysaccharides (shorter chains with the same general structure as cellulose). Starch "toasts" much more easily than cellulose, giving the familiar colors from yellow through brown. One of its components, amylose, dissolves in water to give a clear blue color with iodine. The other dissolves only in hot water to form a paste, and it gives a violet color with iodine. Some of it should have remained after the stiff cloth was washed immediately after manufacture. When we were testing for sulfoproteins in blood areas with an iodine-azide reagent (it bubbles vigorously when sulfur is present), we got a reddish background. The color should have suggested some polysaccharide impurities to us. We should have tested for starch.

Rinaudo's photographs show that protons do not cause a discontinuous distribution of color on his samples. Low-energy charged particles impinging on a dry cloth surface cause the surface to charge. The charged cloth repels later particles of the same charge, especially at the highest and/or sharpest points, the points of maximum potential. Those are the areas that are colored on the Shroud. They appear to be the lightest parts on Rinaudo's samples. There is no evidence for self-charging during image formation, reducing the probability of the involvement of relatively-low-energy charged particles. High-energy particles penetrate to greater depths, making superficial color on the fibrils impossible. Rinaudo did not test a wide range of proton energies. It is unfortunate that the author relied so heavily on Rinaudo's claims.

None of our attempts at Los Alamos, using lasers with different wavelengths and lengths of exposure (down to nanoseconds) gave a discontinuous distribution of color. Neither did our attempts that used corona discharges or electrons. Actually, some tests turned the surface into colorless powder.

When we used a natural-gas/oxygen torch to "paint" a scorch, ablation of the cloth surface produced very hot products that caused the flame to be repelled by the surface. Only the very tops of the weave were colored, as observed on the Shroud; however, the torch burned fibril ends that were sticking up from the surface, producing little carbon balls on the ends. We could not see any carbon balls on the Shroud.

In retrospect, I am embarrassed to point out that most of STURP's attempts to produce an image on linen used modern linen. As the author stated, all failed. That fact does not eliminate all other non-miraculous methods, but it may suggest the reason for failure. We should attempt to produce an image with primitive-technology linen that has been stabilized with starch during weaving and washed in Saponaria to make it supple.

Aging processes might be expected to have changed the composition of the surface of the Shroud since the image-forming event. Age and/or heating in the fire of 1532 has certainly changed the lignin, and it would certainly change other impurities that are less stable than cellulose. Tests of image-formation hypotheses would need fresh material.

Some powerful surface-analytical techniques are now available for looking at molecular structures. Electron Spectroscopy for Chemical Analysis (ESCA) can give direct information on the chemical bond types on a material, and it can be applied to very small

samples. That information would be invaluable in testing both primitive linens of modern manufacture and samples of the Shroud.

The lignin on linen that has been bleached by primitive methods can easily be detected with a very sensitive chemical test under a microscope. The test involves the evolution of vanillin from the lignin. This is the same process that allows you to smell vanillin over new wine barrels and near most warm pine bark. The few uncontaminated Shroud fibrils we had for testing did not show that test, even though you can see lignin at the joints. Preliminary tests showed that lignin gives increasingly weaker tests as it ages over very long times. More work needs to be done on this observation, because it might give an independent estimate for the age of the cloth, similar to the ages we get from tree rings, varves, ice cores, etc. Many microscopic samples from widely different parts of the Shroud would be required, because the fire of 1532 would have accelerated the aging of lignin in some areas.

Early in the STURP studies, Kate Edgerton laboriously made some Roman-process linen that involved both starch and Saponaria. Small samples we got were invaluable for observing the chemical properties of fresh "Roman" linen. We could observe residual lignin at fibril growth joints, the lignin gave intense spot tests, and we could observe components of the Saponaria. We were not able to test later image-formation hypotheses on her samples, because the largest pieces seemed to become "souvenirs." Items associated with the Shroud, even our rubber gloves, tended to disappear into somebody's collection of "relics." We could use more samples for additional tests.

Any radiation that struck the cloth would illuminate the entire surface (illustrate this fact by shining a flashlight on a cloth), but only small areas at the tops of the weave are colored. A very quick touch with a hot iron gives the same discontinuous appearance as the Shroud, but slight, important differences can be detected. If the cloth fell through an energy flux as claimed in the book, effects should be observed at greater depths and all over the surface. The image might appear on *both* sides of the cloth. The Shroud image does not.

With regard to other images on the Shroud, few of us can see them. "I think I can see" is not a substitute for an observation, and observations must be confirmed. When Fr. Francis Filas (deceased) claimed he saw the coins, lituus and all, he was looking at specific photographic prints. He had many prints produced at increasing contrast. Finally, all that was left was strings of dots. It took a numismatist who was familiar with ancient Roman coins weeks to "see" the lituus in those photographs. Your mind tries to make sense out of any "patterns" your eye can see. Psychologists have a lot of effort invested in studying such phenomena.. It is dangerous to build a scientific theory on such shaky foundations. Your mind tends to see what it expects and/or wants to see.

The author proposes an "Historically Consistent Method" for image formation. He claims that with it, all materials "--- behave according to standard physics principles." He then accepts a "theory" that the image was caused by a burst of radiant energy. He quotes Wesley McDonald, as follows: "Many scientists now describe this burst of energy as a

pulsed laser beam caused by dematerialization of the body into energy in a millisecond." Such a statement does not bear any resemblance to "standard physics principles." Incidentally, if the body of an average man dematerialized into energy, the conversion of mass into energy ($E = mc^2$) would mean the evolution of about 200-300 *megatons of TNT*. That is larger than the largest hydrogen bomb ever tested.

The "Historically Consistent Method" proposed by the author attributes many of the elements of speculations to Jackson, Rinaudo, Little, and others. It proposes the complete dematerialization (or passage through a wormhole) of the body with production of protons and other radiation. This process is assumed not to damage the cloth's structure. The protons are assumed to have caused the image. It proposes that the cloth fell through the region where the body dematerialized, solving the problem of vertical, parallel radiation. In falling, the cloth picked up images of some internal features such as bones and teeth, which some observers have claimed to have seen. It also picked up the blood spots, which supposedly could not have been transferred to the cloth by simple contact. I can not identify any solid scientific justification for this series of speculations.

I can recommend the book for its extremely detailed description of the Shroud's appearance and history and the conflicts it has caused. I find the "science" to be totally goal-oriented, to lack rigorous application of Scientific Method, and to be so improbable as to be nonsense.

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