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Review

The Turin Shroud: A Critical Analysis and Rebuttal of a Recent Scientific Study

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ABSTRACT

A recent article has provided a broad yet incomplete overview, particularly concerning the presence and characteristics of the blood detected on the Turin Shroud. The study ignores the three distinct blood types described in various papers, prompting hypotheses regarding their origin in relation to the Passion and Death of Jesus Christ.

This article also fails to address other significant and innovative aspects, such as the selective radioactivity of the Relic, which may explain the unreliability of the 1988 C-14 radiocarbon dating results. Neutron radiation could have induced a nuclear transformation of nitrogen, leading to an enrichment of C-14 in the Turin Shroud's flax, thereby affecting the dating outcome.

Additionally, the most recent hypotheses regarding the formation of the body image, as well as the effects of ultraviolet analysis conducted on photographs of the Relic, are either presented in a biased manner or entirely omitted. Finally, the article's questionable conclusions regarding the relationship between science and faith are critically examined.

This paper does not seek to provide an exhaustive integration of all overlooked or underestimated research from the recent study. However, it aims to address some significant gaps by presenting additional evidence suggesting that the Turin Shroud is the burial cloth that wrapped Jesus Christ after his death and Resurrection.

Introduction

The TS[1] (Turin Shroud or Holy Shroud) is one of history's most studied and debated religious Relics[1-7]. It is a handcrafted linen textile woven in a 3:1 herringbone twill pattern, measuring approximately 4.4 meters in length and 1.1 meters in width. The fabric bears the full-length, front and dorsal images of a human figure, inexplicably impressed upon the cloth. This figure displays wounds consistent with those of a man who underwent severe torture and crucifixion, aligning with descriptions found in the CHB (Christian Holy Bible) regarding the Passion and Death of Jesus, **(Figure 1)**.

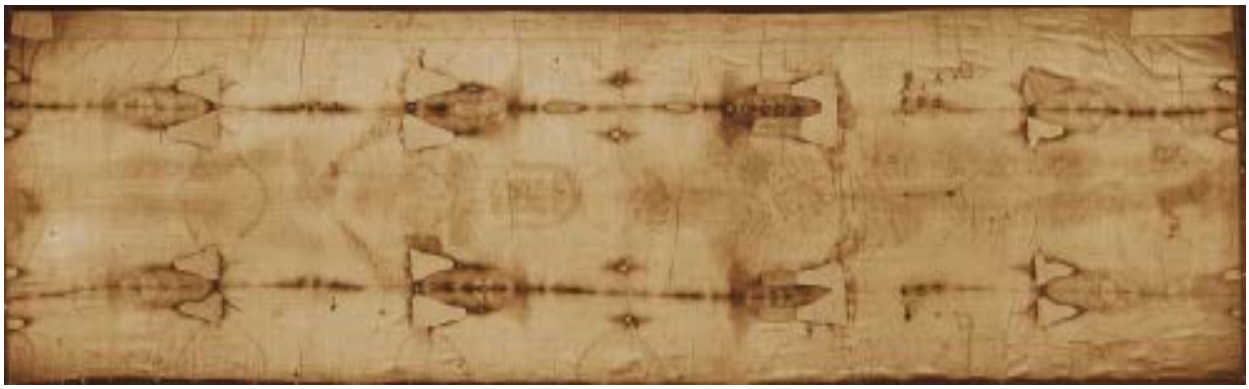

Figure 1: TS photographed by G. Enrie in 1931.

Throughout history, the TS has been venerated as a sacred relic, with documented accounts tracing its presence across various locations over the centuries. Pope Julius II (1443-1513) officially recognized it as an object of adoration[8], cementing its significance within Christianity. Historical analyses suggest that the TS may have been in Byzantium before the Sack of Constantinople in 1204 and later made its way to Chambéry, France before ultimately being enshrined in Turin, Italy, where it remains.

Byzantine coins[9] dating as early as the 7th century depict facial features strikingly similar to those on the TS, fueling speculation that the Relic was known and venerated long before its documented appearance in Western Europe. This resemblance has fueled ongoing speculation regarding its early history and significance.

Until the end of the 19th century, the TS was displayed only on rare occasions, making it difficult to study in detail. However, in 1898, when the lawyer and photographer Secondo Pia captured the first photographs of the Relic, which quickly spread worldwide and marked the beginning of scientific research onto the TS. To this date, the TS continues to challenge scientific understanding, as the formation of its body image remains unexplained and has never been successfully replicated despite numerous attempts. Given the religious significance of the TS and its profound implications, its authenticity was immediately questioned, prompting numerous investigations and scientific analyses.

One of the most controversial aspects of its study centers on radiocarbon dating tests conducted in 1988, which dated the cloth's origin between 1260 and 1390 AD[10] - suggesting a medieval origin rather than a 1st-century artifact. However, this conclusion has been widely disputed due to probable contamination, particularly from environmental factors[11-28] which may have altered the test results.

Some researchers[23,28] have argued that selective radioactivity could have skewed the radiocarbon dating results, with certain hypotheses linking this anomaly to the Resurrection of Jesus Christ. Studies on Beta radioactivity and fluorescence in the bloodstains[28] suggest that the blood on the TS interacted with energy-light in unusual ways, indicating the possibility of an extraordinary event that affected the fabric.

Forensic examinations[29-32] confirm the presence of liquid blood on the TS at the moment of wrapping a human body, with the absence of evidence of smearing, indicating the body was neither moved nor manipulated after bleeding onto the cloth. Additionally, the absence of putrefaction suggests an unusual phenomenon, leading researchers to explore the concept of "material transparency"[30,31] as a possible explanation for how the corpse disappeared from the TS without disturbing its imprint.

A recent article[33] has provided a comprehensive analysis of the most significant studies conducted on the TS to date. However, it omits several crucial recent findings. These omissions may be attributed to the vast and complex body of literature surrounding the TS, which is challenging to manage, particularly due to the frequent presence of contradictory results.

Distinguishing objective historical and scientific findings from those consciously or unconsciously influenced by religious perspectives is often challenging. As a result, some scholars of the Shroud-Science-Group-1 have considered it necessary to highlight aspects that were overlooked or insufficiently addressed in the previous work[33]. They aim to provide a more comprehensive synthesis of recent significant studies on the TS, ensuring a more balanced and complete analysis of the topic.

In particular, Ref[33] claims to focus primarily on the various hypotheses regarding the formation of the body image. However, it overlooks several significant recent updates. While it asserts to analyse the bloodstains, it fails to acknowledge more than a dozen recent scientific publications[1,28-32,34-41] detailing the specific components of blood. Despite these extensive studies appearing in peer-reviewed scientific journals, the presence of blood on the TS is still questioned in the article, where it is labeled as merely "alleged."

Ref[33] extensively discusses the age of TS; however, it emphasizes marginal aspects while neglecting significant findings from recent research, particularly those related to the selective radioactivity of some samples taken from TS. Additionally, while Ref[33] addresses some historical aspects of the TS it overlooks key important historical references, especially those concerning the period preceding the Middle Ages[7,9].

The Blood of the Turin Shroud

As has already been noted, while Ref[33] mentions several times "alleged blood," there are now more than a dozen papers[1-28-32,34-41] that clearly demonstrate the presence of blood on the TS and even divide this blood into three different types[28,31] based on its physical and morphological characteristics.

The same Ref[33] strangely reports that "… the reddish stains … give the appearance of bloodstains and wounds" when all the bloodstains that can be observed on the TS are perfectly consistent in shape and position both with the wounds produced by the tortures suffered by Jesus on the TS and with the description of the CHB (Christian Holy Bible)[31].

Instead, it is highlighted that McCrone[42-48] "disagreed" with these results, explaining that he found Fe_2O_3 and HgS particles as pigments in the bloodstains. Ref.[33] very briefly cites other studies such as that of Lucotte, who confirmed the presence of blood and that of Fanti & Zagotto, who explained the presence of pigments, not sufficient in quantity to form the coloration of the bloodstains, but that were probably due to subsequent contamination by contact with pictorial copies.

Perhaps diverted by some preconceived beliefs, Ref[33] brands these findings of Fanti-Zagotto[39] and Lucotte[40] as unreliable because they refer to a limited number of samples.

Instead, Ref.[33] neglects all the detailed analyses carried out by Fanti[23,28-32] where it is quantitatively demonstrated[28] how much blood was spilled on the TS and how much was contaminated not only by iron and mercury pigments but, by dust consisting of clay and limestone typical of the Jerusalem soil.

It is also neglected that Ref[28] highlights other blood components such as fibrin and creatinine, the latter typical of a severely tortured person. Instead, Ref[49] supporting an artistic origin of the bloodstains is strangely branded as an "interesting investigation" when this has been independently criticized as unreliable by two different groups of experts[50,51] for the overly simplistic and inaccurate analysis performed in that work.

Recent papers[1,28-32] have divided blood particles into three categories: Type A, B and C, based on their microscopic appearance.

Type A blood is typical of that sampled from adhesive tapes placed in contact with the TS by R. Rogers during the STuRP (Shroud of Turin Research Project) campaign in 1978, and is very similar to that published by Kohlbeck, et al. in Ref[52]. It consists of numerous reddish particles present on the adhesive tapes both adhering to the flax fibers of the TS and isolated in the adhesive of the tape. The elemental composition of this material is compatible with that of blood particles.

Most of the particles adhere to the fibers sampled on the tape, but some are dispersed in the adhesive. The appearance of these discoid particles is donut-shaped with a central concavity, very similar to an erythrocyte, where the elements contained in them are compatible with those of the blood (Carbon-C, Oxygen-O, Iron-Fe, Calcium-Ca, Chlorine-Cl, Nitrogen-N, Potassium-K and Phosphorus-P).

As their dimensions vary from 0.3 to 2 micrometers with a prevalence of 0.7 micrometers, one can, therefore, assume that these particles are microcytes or parts of them. Two hypotheses can be formulated: either they derive from non-coagulated blood that has undergone a strong contraction (preferred) or these particles could be apoptotic bodies deriving from echinocytes (erythrocytes that have short, rounded protuberances) that indicate a pathology such as traumatic kidney injury that have fragmented and dispersed in the plasma.

Experimental tests with human blood mixed with urea, aloe and myrrh have shown that erythrocytes can be reduced much more than those found in Egyptian mummies of Ref[53] having dimensions of 4-5 micrometers.

Incidentally, since Jesus suffered from very high traumatic kidney injury due to flagellation, which induced renal (and also hepatic) failure, this transformation of erythrocytes causing microcytic anemia suggests the extreme difficulties He had in oxygen exchange, causing extremely labored breathing.

Noteworthy is that among these microcytes no whole leukocytes were found, which would be typical of a living person[28]. Therefore, it seems appropriate to identify this Type A blood as post-mortem.

Finally, it is noteworthy that this Type A blood is fluorescent and shows an intense Beta activity (consisting of an electron emission). This clearly indicates a radioactivity of the material that may have produced nuclear reactions in the linen of the TS and that could have transformed nitrogen into carbon 14. Ref[23], confirming this hypothesis shows the anomalous lack of nitrogen in the blood of the TS.

Type B blood[28] consists of fragments of compact, but fragile, crusts darker than Type A blood. It is rarer than Type A blood. Its elemental composition is compatible with that of blood, and its dimensions are up to a tenth of a millimeter; it has shapes that are not rounded but with edges that suggest previous fragmentation of larger particles.

This blood appears to be pre-mortem blood that coagulated on the skin from open wounds when Jesus was still alive.

Type C blood[28] consists of very rare donut-shaped particles found only in the TS dust aspirated from the back of the face (Filter-f).

The particle size varies from 2 to 6 micrometers and has a structure compatible with that of erythrocytes. Initially, in too small quantities to be definitively recognized, these particles were later better identified in Ref[1] as probable residues of blood sweating that have swelled following immersion in a hypotonic liquid such as human sweat.

(Figure 2) shows the SEM-FEG photo of a presumed red blood cell that Ref.[1] has hypothetically related to the hematidrosis of Jesus in the Gethsemane.

The Body Image of the Turin Shroud

In reference to body image, Ref[33], after describing the results obtained by STuRP, still focuses on describing hypotheses of body image formation of human origin, widely criticized[54,55] and considered unrealistic for many years.

However, Ref[33] does not report any criticism of these hypotheses and reports a simple objective description summarizing the corresponding published works, strangely making itself still possibilist on these unrealistic hypotheses. This is the case, for example, of Craig and Bresee[56], in which Fanti had the opportunity to study experimental results and critically analyze Ref[54] in detail.

Ref[33] also mentions Fanti's hypothesis of image formation, but it describes it only in reference to an obsolete publication from 2010[57]. In fact, it reports the hypothesis that the body image was formed due to an intense electric field that produced a CD (Corona Discharge), but limits itself to stating that Fanti referred to a possible earthquake, when in fact, the hypotheses analyzed in that paper were many, some even linked to the hypothetical energy of the Resurrection.

Ref[33] completely ignores the latest publications made by the same author after 2018, Ref[58-60], where Fanti revises the previously published hypotheses on CD. This review was done in light of

the Maillard reaction in conjunction with effects similar to those relating to the Holy Fire that has been developing annually for several centuries inside the Holy Sepulcher in Jerusalem.

The hypothesis related with the CD produced by an intense electric field was first formulated by Arthur Loth[61] in 1900, who suggested that a bolt of lightning could explain the body image; recently, some scholars such as Francesco Lattarulo[62] and Giovanna De Liso[63] proposed a CD of natural origin perhaps related to an earthquake.

Other scholars like Oswald Scheuermann[62,64], Giovanni Battista Judica Cordiglia[65] and Alan Adler[66], supposed something similar to a CD produced by the corpse wrapped in the TS. Fanti[57] obtained a negative frontal body image from a TS-like sheet wrapping a manikin covered with conductive paint and put through a 300,000 V tension.

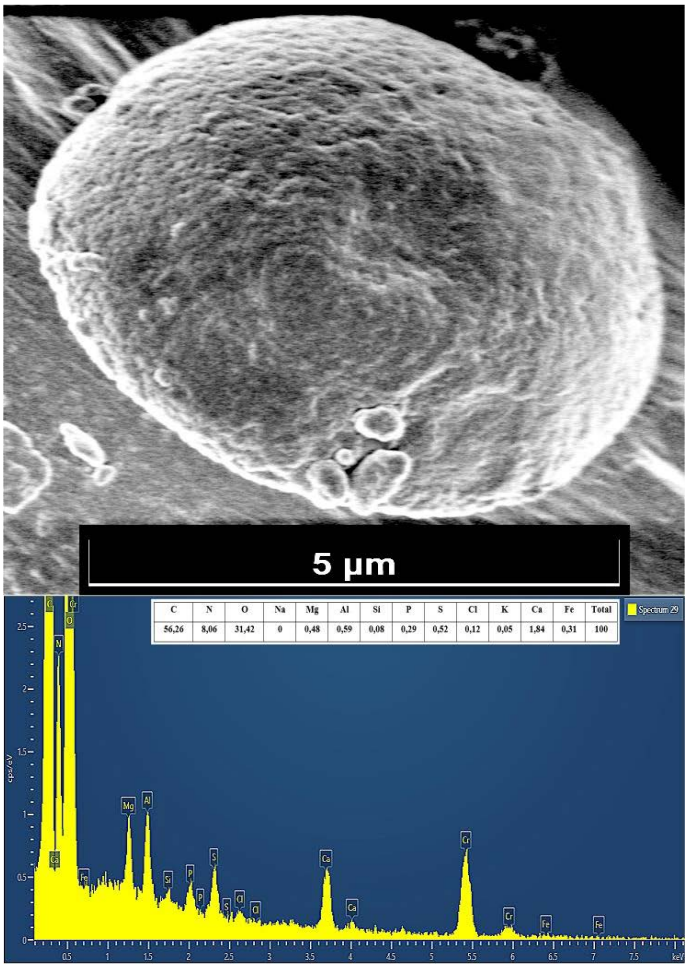

Figure 2: Recently detected erythrocytes classified as Type C blood.

In 2019 Fanti[58-60], after analyzing the effects on linen fabrics of the HF (Holy Fire, a miraculous fire that repeats every year in the Holy Sepulcher of Jerusalem on Holy Saturday), formulated a hypothesis that relates to the body image formation, calling it Divine Photography Hypothesis (DPH).

To complete the explanation of the formation of the body image, the hypothesis of a chemical (Maillard) reaction based upon the contact between sugars of the linen fabrics and amines coming from the urea exuded by cadaver was added to the CD hypothesis to formulate the DHP. Details of this hypothesis can be found in Ref[59,60] but they are summarized as follows.

- **Assumptions.** The TS wrapped the body of Jesus Christ when he was laid in the rock-cut sepulcher now enclosed by the Edicule of the Holy Sepulcher of Jerusalem. A mixture of myrrh and aloes used for burial, also composed of sugars, was used and spread around the whole corpse. This mixture was a means of transmission between the cadaver and the sheet of the post-mortal fluids exuded from the cadaver, such as urea.
- **Initial conditions.** The kidneys of Jesus, during the scourging, were seriously compromised with consequent excess of urea in the blood. The corpse remained wrapped in the TS for 30-40 hours and placed in the humid environment of the tomb. In this period, the corpse exuded fluids rich in urea. Depending upon the thickness of the amalgam, the concentration of urea varied from one area to another, and this concentration was responsible for the 3D body image formation on the TS.
- **Reagents.** Urea hydrolyzed by CD, which also heated the environment to temperatures around 50-100 °C, produced amines. Sugars from the aloe and myrrh in the amalgam formed the second part of the reagent for the DPH.
- **Energy.** During the Resurrection, a light-energy very similar to the HF, and an intense electric field generated a CD. Instantaneously, the Body of Jesus became materially transparent[30,31]. The TS collapsed under the force of gravity onto the sepulchral stone and the "photography" formed on the TS. The CD produced electrons which were concentrated mainly at the tips and protuberances of the linen fibers on the threads of the TS's fabric. The fibers then produced selectively localized chemical reactions that formed the body image.
- **Image transfer.** The directionality of the electric field (like CD, having the lines of forces perpendicular to the emitting body, the human skin) allowed information relating to the human body to be encoded on the TS with sufficient resolution.
- **3-D effect.** The chemical reactions on the linen lessened with increasing distance of the sheet from the body, thus encoding the 3-D information related to the body-cloth distance.
- **Reaction.** A cold plasma similar to the HF, which contains negative ions, produced CD at low temperature (<200 °C). Reducing sugars interacted with amino acids of the urea, giving rise to the initial products of the Maillard reaction: a latent image resulting on the linen fabric.
- **Development.** With time, the invisible defects produced by the Maillard reaction activated by the HF energy on the linen fibers, oxidized and produced a visible image.
- **Results.** Several laboratory tests were carried out to verify the DPH by subjecting a 50 mm bronze medal of John Paul II wrapped in a linen fabric to voltages of about 20 kV. The **(Figure 3)** shows the results of these tests.

Ref[33] completely neglects to mention Rucker's hypothesis[67] of body image formation; Ref[33] supposes that neutrons were emitted from the body that shifted the carbon date forward from the actual date, but then how were neutrons emitted from within the body? Rucker answers this in his proposal for how the images were formed. This is called the Vertically Collimated Radiation Burst (VCRB) hypothesis. This hypothesis was developed considering 27 pieces of evidence from the TS.

By following the cause-and-effect relationships back from these 27 pieces of evidence to the root cause, the VCRB hypothesis proposes that there was an extremely high-frequency vertical oscillation of the nuclei in the body that was sufficiently energetic to cause deuterium nuclei in the body to split, thus releasing low energy protons that formed the images and neutrons that shifted the carbon date forward.

Deuterium is an isotope of hydrogen. It is also called heavy hydrogen (H-2) because it contains a neutron and a proton in the atom's nucleus. In this proposed oscillation of the nuclei in the body, the nuclei that would preferentially split would-be Deuterium nuclei because it requires the least energy input to split. This is because it is on the far left of the "binding energy per nucleon" curve[68].

Figure 3: Experimental results regarding the DPH. A negatively charged bronze medal (25 kV) covered by a dry linen sheet previously impregnated with urea and myrrh was placed on an insulator. A doubly superficial image on a linen sheet was then produced. On the top are the two superficial images, front and back, with the photo of the bronze medal in the middle. On the bottom is a 3D rendering of the image in question.

A Deuterium nucleus requires an energy input to cause it to split, and there is no energy release in the process. About 2 x 10^{18} neutrons are required to be emitted in the body to shift the carbon date at the 1988 sample location from about 33 AD to 1325 AD, which is the midpoint of the mean carbon date of 1260 to 1390 AD. This means that only about one neutron would have to be emitted per ten billion neutrons that were in the body.

This would be accomplished by splitting only about 0.0004% of the Deuterium nuclei in the body. Due to this proposed vertical oscillation of the nuclei in the body, the protons were preferentially emitted in the vertical direction, with this direction oscillating between vertically up and vertically down directions.

According to this hypothesis, this caused oscillating corona discharges between the body and the cloth above and below the body, which caused an alternating current in the fibers. This alternating current caused oscillating electric and magnetic fields that caused the electron flow in the fibers to be primarily in the outer radius of the fibers.

This is called the "skin effect of an alternating current". The alternating electric current flowing in the thin outer radial region of the fibers would cause heating in this thin region, which would discolor it around the circumference of the fiber. The thin discolored region around the circumference of the fibers, in the top two or three layers of fibers in the threads, causes the full-size front and dorsal images of the crucified Man that can be seen on the TS.

The 1988 Radiocarbon Analysis of the Turin Shroud

The carbon dating of the TS is the main reason many believe that the TS dates to the Middle Ages. In 1988, samples were cut from a corner of the TS for carbon dating at three Arizona, Zurich, and Oxford laboratories. Each of these laboratories cut their sample into smaller pieces, so twelve subsamples were carbon-dated in 1988[10].

The mean carbon date of these twelve subsamples (1260 to 1390 AD) was interpreted by many to indicate that the TS could not be the authentic burial cloth of Jesus. However, several recent papers on the statistical analysis of the carbon dating values conclude that the TS samples were heterogeneous and, therefore, the 1260 to 1390 AD result was unreliable[11-27].

In reference to Section 4.1.1 of Ref[33], the author acknowledges that "...deviations were adopted in the updated protocol compared to the original plan" and illustrates this with the decision to reduce the number of laboratories involved in the test from seven to three. However, other changes had a much greater detrimental impact on the integrity of the test, in particular, the decision to remove just a single sample from a corner of the cloth. This decision ignored advice from scientists from the International Radiocarbon Calibration Program headquartered at Glasgow University, who recommended that a minimum of three samples be taken from disparate areas of the TS for a reliable result[69].

This was also the view of archaeologists with several years' experience using radiocarbon dating, as well as scientists from the Applied Science Center for Archaeology at the University of Pennsylvania.

In Section 4.1.2 of Ref[33], the author states, "Very good agreement in the reported results among the three laboratories for any tested sample was observed." While this was true for the results reported by the laboratories for the three control samples, it certainly cannot be claimed that there was "very good agreement" with the results obtained from the sample removed from the TS.

According to the test report published in Ref[10], a chi-square test was applied in accordance with the recommended method of Ward and Wilson[70] to detect statistically significant inconsistencies in the radiocarbon dates.

The chi-square value obtained after consolidating the laboratory results for the TS was 6.4, which exceeds the critical value of 5.99. The significance level was also reported as 5%. (The value calculated using the laboratory results reported in Ref[10] is 4.18%). This value appears to have been rounded up to 5% rather than down to 4%), which indicates that there is less than a 5% probability that random measurement errors were responsible for the observed differences in the individual measurements obtained by the labs. This implies a greater than 95% probability that a systematic error was responsible for these differences in the TS dating measurements.

The most plausible source of this systematic error is some form of contamination that introduced differences in the C^{14}/C^{12} ratios within the TS samples tested by each laboratory.

Subsequent analysis of the laboratory test results has provided clear evidence of contamination[15,19,20,22,69]. It has confirmed the existence of a statistically significant connection between the measured age of the fabric and the distance along the length of the 7 cm by 1 cm strip[10] of linen removed from the TS, as if the C^{14}/C^{12} ratios of the 12 subsamples had been altered as a function of the distance from the short end of the cloth.

There is, therefore, clear evidence that the sample tested was not homogeneous, invalidating the test report conclusion that the linen of the TS dates to AD 1260 to 1390.

Below are listed some date indicators, other than carbon dating, that argue for a much earlier date.

- The TS existed long before the fall of Constantinople in 1204 AD. Coins were rubbed onto the TS. They left micro-particles of gold-alloy metals (electrum) on the TS, consistent with the history of the composition of coins during the Byzantine empire[18].
- The Hungarian Pray Manuscript, historically dated 1192 to 1195 AD, indicates the TS existed earlier than 1260-1390. It contains a colored diagram that can be identified as the TS based on several features, especially the L-shaped pattern of four holes on the TS[7].
- Ancient coins that contain the same image as the TS go back to 692 A.D.[9], demonstrating that the TS could not have been copied from the coins. The TS body image is not explained even today.
- It is believed Jesus' face or head cloth is in Oviedo, Spain, based on historical documentation that arrived with it. It is called the Sudarium of Oviedo. It has blood stains similar to those on the TS. Historical documentation dates it to 570 AD in Jerusalem. The evidence that the Sudarium and the TS covered the same body indicates that the TS can also be dated back to at least 570 AD[71,72].
- Ancient paintings and other works of art that contain the same image as the TS go back to about 550 to 600 AD; therefore, the TS must have existed by about 550 AD.
- The image on the TS is that of a crucified man coherent with knowledge of Roman crucifixion. Constantine the Great abolished crucifixion in the Roman Empire in 337 AD, and details of crucifixion have been gradually forgotten after this date.
- The image on the TS is that of a naked man who was crucified exactly as the HCB says that Jesus was crucified. It is impossible even today to explain how an artist could have produced the image[29,32]. Therefore, the image must somehow have been produced from a human body wrapped in the TS.
- Fibers from the TS show damage from sources of natural background radiation. Chemist Ray Rogers discovered that the radiation damage to the TS fibers indicates that the TS fibers are similar to flax fibers from the Dead Sea Scrolls[13], which date back to about 250 B.C. to 70 AD.
- Raman Spectroscopy of samples from the TS produced a date of 200 B.C. ± 500 years[73].
- Fourier Transform Infrared Spectroscopy (FTIR) of samples from the TS produced as date of 300 B.C. ± 400 years[73].
- Tensile strength of flax fibers coming from the TS produced a date of 400 AD ± 400 years[6].
- Wide-angle X-ray scattering (WAXS) of the TS indicated a date of the first century for the TS[24,25].

In reference to Section 4.2.5 of Ref[33], the author dismisses the hypothesis that neutron radiation may have caused the false radiocarbon dating results because "...the hypothetical conversion of carbon atoms was not supported by any scientific evidence".

This statement is the author's response to a hypothesis by T.J. Phillips[11], who in 1989 proposed that radiated neutrons could have converted carbon-13 into carbon-14, leading to false radiocarbon results. However, the author ignores the experimental evidence that nitrogen atoms in linen fabric are converted to carbon-14 when exposed to neutron radiation[23]. This nitrogen-14 to carbon-14 conversion and not an alleged conversion of carbon-13 to carbon-14 atoms is the basis of the neutron absorption hypothesis.

Nuclear engineer Rucker is convinced that the 1988 TS radiocarbon dating test produced a wrong (medieval) date due to neutron absorption on the TS linen that transformed an amount of nitrogen N-14 to new C-14 atoms by the $N^{14}(n,p)C^{14}$ reaction shifting the carbon date forward from the actual date. He has used the MCNP (Monte Carlo N-Particle Transport Code) nuclear analysis computer code to analyze carbon dating measurements related to the TS[17,67].

Starting from a belief that the equipment used for the 1988 carbon dating of the TS experimentally determined the correct C^{14}/C^{12} ratios, he concluded that the 1988 carbon dating of the TS is one of the best pieces of evidence for the authenticity of the TS. This surprising conclusion is based on the results of Rucker's MCNP nuclear analysis computer calculations in 2013[17,67].

- There is a specific range and distribution of the carbon dates for the 12 subsamples that were dated.
- The mean dates of the three laboratories indicate that the carbon dates are likely a function of the distance from the short end of the cloth with a slope or gradient of about 36 years per cm (about 91 years per inch). At this rate, moving the sample location 25.4 cm further from the short end of the cloth would shift the carbon date about 910 years further, to the range of 2170 to 2300 AD, i.e., to the future. This slope to the data indicates a systematic error in the measurements likely due to a non-uniform neutron radiation.

So far, a discussion has been reported on why the C14/1988 result is unreliable and several pieces of evidence have been presented in favor of this supposition. Fanti also shares this evidence, but conceives it as follows.

Its basic idea is that the three laboratories that performed the C14/1988 analysis on the TS correctly measured the isotopic ratio between C-14 and C-12, even if they assigned to the result an uncertainty that was too small given the sample analyzed and the statistical inconsistency that emerged.

However, the result published in Ref[10] is affected by an evaluation performed by the laboratories and their Coordinator, Michael Tite that was too hasty and, therefore, unreliable.

They did not test a possible selective radioactivity present in the TS[23,28,31] that certainly influenced the results obtained, producing a systematic effect of a non-negligible entity.

According to Fanti, who measured intense Beta radioactivity in the Type A blood samples and perhaps also the presence of a Gamma activity in other samples, including tissue[28], this radioactivity certainly interfered with the elements contained in the flax cellulose, altering the isotopic percentage of Carbon and therefore rejuvenating the analyzed sample even more than a thousand years. Ref.[23] evidences this and comments on the nuclear reaction $N^{14}(n,p)C^{14}$ reaction. It is curious to note that Ref.[33] states, "However, the hypothetical conversion of carbon atoms was not supported by any scientific evidence."

Suppose this selective radiation is confirmed using larger samples of the TS. In that case, the C14/1988 test will not be considered proof of the medieval age of the TS - as many persist today in claiming against all the reported unambiguous evidence of the contrary - but rather it will be proof that an intense nuclear reaction occurred in the TS linen that selectively altered its isotopic ratio.

Nevertheless, what nuclear reaction can one think of as having occurred two thousand years ago in the sepulcher hidden in the rock and sealed by a stone in Jerusalem? For agnostic scientists, this will be a major puzzle. However, for Christians who believe in the CHB, the answer is simple: the Resurrection of Jesus Christ produced this very particular nuclear radiation that was so intense as to produce the desired effects, but at the same time, it was so limited as not to produce apparent damage to the sepulcher and the city of Jerusalem.

An additional hint of the validity of this hypothesis is the observed fluorescence of the TS explained below[74,75].

The UV Analysis of the Turin Shroud

Ref[33] omits any consideration of the important analysis performed by T. McAvoy other than a superficial comment that his research paper "was used to discuss the UV fluorescence properties of the Shroud". Strangely, it ignores the important and highly relevant discoveries revealed by McAvoy's research[75-77], and the key points are summarized below.

Ultraviolet (UV) light can detect molecular properties of linen. These properties would include any molecular bonding differences and contamination. In the case of the TS, possible differences in its burned or blood regions could also be detected. Any UV detection is relative in that one can only conclude that a linen sample is not uniform and its molecular properties vary with position. Additional information is required to conclude just what caused the variation.

When linen absorbs UV radiation, its electrons are raised to a higher energy state. As the electrons return to their original state, visible light energy is released. This process is called ultraviolet-induced fluorescence (UVIF) and, can be measured. Fluorescence photography and fluorescence spectroscopy have been used to measure UVIF from the TS.

As part of the STuRP project, Vern Miller, the official photographer, took high-quality UVIF images of the TS. Seven of Miller's UVIF images were published in 1981[78].

Miller's original UVIF images were lost, but high-quality transparencies made from them were published as jpegs on the web in 2019[79]. In a series of recent papers[75-77] McAvoy has analyzed these UVIF TS images. The TS is large enough that Miller could not take a single UVIF photo of the cloth. Miller used a rail system and took UVIF photos down the TS along its top, middle, and bottom parts. When the intensity of the UVIF images was plotted versus position, the interesting patterns shown in **(Figure 4)** were found.

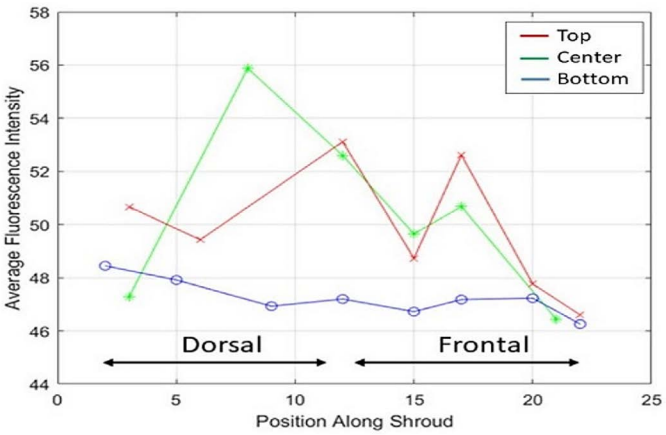

Figure 4. UVIF intensity along TS taken from Ref[76]

The results in **(Figure 4)** show that fluorescence intensity varies with the location on the TS that is photographed. As can be seen, the highest intensity is ~56 and the lowest just over 46. The intensity for the top of the TS is always higher than that of the bottom and the highest intensity occurs in the dorsal center image. These results indicate that the molecular properties of the TS are not constant, but vary with location.

Roger Gilbert and his wife Marty were STuRP members, and they measured UV fluorescence spectra at 16 points on the TS[80,81]. Their measurements were closer to point measurements compared to the large size of the regions photographed by Miller. Gilbert and Gilbert measured fluorescence spectra on the cloth at 4 clear, 3 blood, 5 burn, and 4 image points.

McAvoy analyzed a reconstructed database of Gilbert and Gilbert's fluorescence spectra and found that the intensity of the spectra varied with location[77].

These spectral UV results corroborate the UVIF results calculated from Miller's images. Of interest is that the spectral results for the 4 clear and 4 image spectra showed variation similar to that of the UVIF images and these spectral areas were not contaminated with blood and were not burned. Since it is doubtful that contamination alone could cause both the variation in the UVIF images or the spectral results, McAvoy concluded that the molecular bonding in the TS's linen varies with location[77].

An important question to ask is what could cause a variation in the molecular bonding properties of the TS. Several types of radiation have been shown to affect the fluorescence of linen. These include corona discharge[57] and deep ultraviolet radiation[82].

In addition, the fluorescence intensity patterns in Figure 4 show a close similarity with patterns published by Rucker[17] for a simulation of Phillips' hypothesis[11] that the body wrapped by the TS emitted neutron radiation.

This similarity led McAvoy to carry out neutron irradiation experiments of modern linen[21]. He found that neutron radiation also changes the fluorescence intensity of linen. Subsequently, it was learned that the neutron reactor used by McAvoy also exposed his samples to some gamma radiation which could have caused their fluorescence variation[77]. Thus, radiation is one potential cause of the variation in the TS's molecular bonding

properties. Are there any other non-radiation phenomenon that could cause this variation?

On the Science-Faith Relationship

Ref[33] in Section 5 writes: "It is the inalienable right of each individual to believe or not believe in the miracle of the Resurrection. However, if one accepts the authenticity of the Shroud and believes in the Resurrection, it is a rather oxymoronic attempt to explain an effect (i.e., the image formation) of a supernatural miracle through science. A miracle goes beyond human understanding and defies the laws of science.

For the believer, the essence of the Resurrection is precisely that human logic collapses. Therefore, any attempt to explain the mechanism behind the formation of the Shroud image is likely to be utopian, as long as it presupposes that the Shroud is authentic and that it was exposed to the supernatural conditions of the Resurrection …."

This statement, rooted in positivist thought, seems questionable from different points of view, even in the scientific field, because positivist science cannot be made an idol. Positivist science, which draws certainty exclusively from the thought of the experimental sciences based on observation, using mathematics as the primary resource and works trying to know the laws of nature, is limited because it is based on human knowledge, which is limited by definition.

It is absurd to think, as positivism suggests, that there is no other reality than natural fact and no other possible knowledge outside of science. Miracles, for example, which Fanti studied scientifically at the university level[83], are a clear example of this.

In this view, it is certainly not stupid to approach the supernatural and, therefore, the Resurrection with human reason and science, simultaneously in the humble awareness that human science cannot explain everything. Science, instead, has the task of investigating and understanding. Putting human science and the supernatural side by side is not an oxymoron but a commandment of the HCB: "… subdue the earth …" (Genesis 1:28).

There are no contradictions between science and faith, but both seek to explain hidden realities. St. John Paul II affirmed in Fides et Ratio: "Faith and reason are like two wings on which the human spirit rises to the contemplation of truth". A. Einstein, in other words, affirmed the same concept: "Religion without science is blind. Science without religion is lame".

Faith generally comes to be understood more quickly because it relies on the Word of God, so it is certainly legitimate to try to verify through science what happened during the Resurrection. Of course, with its current physical understanding of the facts, science cannot affirm with certainty that the TS is proof of the Resurrection. However, there are objective physical realities about the TS that could not exist according to simple positivist analysis, such as the inexplicable radioactivity of Type A blood[28,31] or the "materially transparent" passage of the human body wrapped in the TS before putrefaction[30-32].

Even in this case, therefore, science verifies and supports what faith teaches. Even for the TS, the criterion for understanding the phenomena hidden therein is "scientific humility", which recognizes that there are realities that go beyond positivist thought.

If someone does not believe in God, it is difficult for these people to assume that both faith and science (reason) were instituted by God for man. It is also difficult to accept that the laws of nature given by God can be ignored by Him at any time or can follow other laws: faith, in fact, recognizes the hand of God globally in the laws of nature as well as in miracles.

It is also difficult for these people to admit the close connection between science and faith; for this reason, positivist science still finds some acceptance. Therefore, the authors of this paper understand the position of Ref.[33], but categorically reject it in light of what has been exposed.

It is, therefore, completely legitimate to want to understand and explain the greatest miracle - the Resurrection of Christ - in the light of the scientific evidence inherent in the TS. After all, humans are not master of life and death because no man has self-created, and without the Resurrection no one would know what happens to them after death. Therefore, science and faith do not contradict each other, but travel on two parallel roads that at a certain point meet and compare to enrich each other.

Latent skepticism is frequently a sign of arrogance. An arrogance that hides under the guise of positivist science. After all, this skepticism masks the fact that there are realities that go beyond positivist science and these realities are a door to new unimaginable discoveries.

In the case of the TS, the recent Refs[29-32] findings show that the wrapped human body remained in the tomb in a state of cadaveric rigidity and without signs of putrefaction, which implies that it remained there for no more than about forty hours, precisely the time indicated by the CHB as between Good Friday and Easter Sunday.

However, the fact that the bloodstains, many still in the liquid phase, did not cause smearing on the linen fabric of the TS implies that there was no relative movement between the body and the sheet.

The following question then arises, apparently without a scientific answer: how did Jesus come out of the TS? Science stops here, at least for the moment, but faith in the Resurrection of Christ from the dead provides a clear explanation.

Obviously, we cannot claim to demonstrate the Resurrection through the TS scientifically. However, we can try to find scientific clues in the TS that can confirm that those phenomena that occurred in that linen sheet are coherent with what we believe, from the point of view of faith - can be correlated to the Resurrection.

Concluding Remarks

This paper has been written in response to Ref[33] which claims in the title to perform an overview of the archaeological scientific studies on the TS but which, in fact, appears to be a limited and at least partly goal-oriented report.

The analysis that the reader would expect should be equally comprehensive of the studies carried out on the TS, the most important Relic of Christianity. Instead, as it appears from the present paper, some studies, such as those regarding the UV analysis, have been practically forgotten; the analysis regarding the C-14 radio-dating performed in 1988 has been there reported in a distorted way, neglecting some fundamental points that demonstrate the scientific unreliability of the medieval result.

Forgotten in Ref[33] is the hypothesis of an alternative explanation, presented by the authors of this paper, regarding the revision of the result published in Ref[10] about the 1988 radiocarbon result, which is a perspective of indisputable contamination, probably caused by neutron irradiation. This is in favor of the hypothesis of the effects of the Resurrection of Jesus Christ.

Even the presentation of the hypotheses of body image formation, still today inexplicable and even less reproducible, presents notable gaps in Ref[33] especially regarding the hypotheses formulated by Rucker and Fanti, which have been summarized here for completeness.

As for blood, an element of primary importance in TS, Ref[33] brands as "alleged blood" that "gives the appearance of bloodstains and wounds", completely ignoring a series of scientific papers[1,23,28-32] discussing in detail, the types of bloods evident characteristics. Are the various erythrocytes, creatinine and fibrin highlighted in these studies' indicative of a substance other than blood?

The incomplete and slanted description in Ref[33] can be partly justified because the topics regarding this Relic are very numerous. There are hundreds of scientific articles published in prominent refereed journals, and consequently, a scholar's review work does not appear easy.

It is also known that a scientific paper has value if it is treated objectively, but in the case of the TS, it is not easy to maintain this objectivity. Often unconsciously, a particular religious belief or view tends to make the result slanted. This also seems to be the case with Ref[33] where some important facts in favor of the Relic's authenticity reported above, appear to be partially underestimated or even disregarded.

Therefore, this paper, while not aiming to reach the completeness of integrating all the research passed over or underestimated in Ref[33], at least tries to fill some very evident gaps in that article by adding a bit of evidence that the TS is the burial cloth that wrapped Jesus Christ after His death and Resurrection.

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Ethical Statements

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Conflicts of Interest

The authors declare no conflict of interest.

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