

EVIDENCES FOR TESTING HYPOTHESES ABOUT THE BODY IMAGE FORMATION OF THE TURIN SHROUD

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FOREWORD

This paper has been written in honour of the lamented Raymond Rogers who first proposed this work and dedicated many hours of his life to improve this collection of information; he wrote:

*“No matter what the truth is about the Shroud, it is a fascinating study.
It can be studied according to the rigorous Scientific Method,
and it is too bad that so many wild flights of fancy have destroyed the credibility of the studies.
Maybe we can restore some science to the discussions.”*

ShroudScience Group and the present paper are a first effort to realize Ray's hope.

SUMMARY

This paper is the first document, still in progress, that derives from a very wide discussion on the Yahoo! Shroud Science Group and has the aim to present all the evidences detected on the Turin Shroud that can be useful for a further discussion about the problem of the body image formation. Many hypotheses about the image formation have been proposed, but, up to now, none, scientifically testable, satisfies simultaneously all the facts detected on the Shroud.

The Group has the aim to consider in depth, all the possible hypotheses proposed or to improve some others in order to determine if some mechanism, more or less complicated, is able to explain all the many peculiarities of the Shroud.

This aim is not simple because the Group has no access, for the moment, to the results of the new tests on the Shroud made under the guidance of Prof. P. Savarino, scientific consultant of the Custodian Card. S. Poletto, in 2000 and during its "restoration" in 2002. In any case the Group has re-analyzed many data also coming from tests done in 1978 by the STURP (Shroud of TURin Research Project) Group and has collected considerable information that clarifies the complex aspects of this sheet; hopefully this information will be improved upon when the Turin data becomes available.

In this document a list of facts directly related to the Turin Shroud, subdivided in four sections, is presented. The first section describes unquestionable facts detected on the Turin Shroud; the second one refers to confirmed observations or conclusions based on a proof made in reference to Turin Shroud studies; the third one refers to facts or observations that were evidenced by some researcher but that are not universally accepted; the fourth one, assuming a scenario that the Shroud is actually the burial cloth of Jesus of Nazareth, includes correspondences with the Scriptures.

1) INTRODUCTION

The Turin Shroud (TS) is believed by many to be the burial cloth of Jesus of Nazareth when he was put in a tomb in Palestine about 2000 years ago. It has generated considerable controversy but unlike other controversial subjects (e.g. flying saucers and ghosts), the TS exist as a material object: it can directly and objectively be observed. The results of studies can be analyzed by scientific methods (Schwalbe 1982).

The TS is a linen sheet about 4.4 m long and 1.1 m wide, in which the complete front and back body images of a man are impressed. Of all religious relics it has generated the greatest interest. The cloth is hand-made and each yarn (diameter about 0.25 mm) is composed of 70-120 linen fibers. Although not all scientists are unanimous, it has been shown by many scientists that the linen sheet enveloped or wrapped the corpse of a man who had been scourged, crowned with thorns, crucified with nails, and stabbed by a lance in the side. Also impressed are many other marks due to blood, fire, water and folding, which have greatly damaged the double body image. Of greatest interest are the wounds which, to forensic pathologists, appear to be unfakeable (Fanti and Moroni 2002).

The "Shroud of Christ" appeared in 1353 in Lirey, France, under mysterious circumstances and with no documentation whatever. In 1203, a soldier camping outside Constantinople with the Crusaders, who sacked the city the following year, noted that a church there exhibited every Friday the cloth in which Christ was buried, with the figure of his body. It is probable that this cloth and the TS are the same. It seems that the TS was among the spoils of the Crusades, together with many other relics brought back to Europe. Before the sacking of Constantinople in 1204 there are some documents that refer to the presence of the TS: for example some characteristics of the Christ reproduced in some Byzantine coins (gold-solidus) of the VII-XIII century A.D. are very similar to those of the TS body image.

I. Wilson (1998) identified the TS, folded four times to show only the face, with the Mandyllion, a cloth said to have received the miraculous imprint of Christ's face and to have been taken to Edessa in the first century A.D.. The tradition of this imprint "made without hands" developed first in the

Byzantine empire; a similar tradition arose in the 7th and 8th centuries in the West - that of Veronica, who wiped the brow of Christ with her veil and found an imprint of his face remaining.

Scientific interest in the TS developed after 1898, when S. Pia, who photographed it for the first time, noticed that the negative image on the TS looked like a photographic positive. Correlations with the anatomical characteristics of a human body were also very high and not comparable with anatomical characteristics normally depicted in popular Medieval art. In 1931, G. Enrie again photographed the TS at a very high resolution.

The TS has a front image 1.95 m long and a back image 2.02 m long, separated from the former by a non-image zone of 0.18 m (measurements done before 2002); the images show an adult male, nude, well proportioned and muscular, with beard, mustache, and long hair.

The TS has been radiocarbon-dated to 1260-1390 A.D. (Damon et al. 1989) but a great number of scientists believe that the method used to take the sample and the reliability of radiocarbon dating is not satisfactory because the linen underwent many vicissitudes (e.g., fires, restorations, water, exposure to candle smoke and the breath of visitors). For example, some researchers have proposed that the 1532 fire probably modified the quantity of radiocarbon in the TS, thus altering its dating, and others believe in the existence of a biological complex of fungi and bacteria covering the yarns of the TS in a patina (Moroni 1997, Garza Valdes 2001). Recently it was demonstrated that the 1988 sample is not representative of the whole TS (Adler 1999 and 2000, Marino 2000 and 2002, Rogers 2002 and 2005).

Many hypotheses and experimental tests have been carried out on linen fabrics to explain the formation of the body image, both in favor of authenticity, and vice versa. Examples are:

- a) The body image is caused by the emanation of ammoniacal vapors (Vignon 1902).
- b) The body image is due to a chemical process similar to that which happens in leaves of herbaria: the image originated through direct contact (De Salvo 1982, Volckringer 1991).
- c) The body image is a painting (McCrone 1980).
- d) The body image is due to a natural chemical reaction (Rogers 2002).
- e) The body image was obtained from a warmed bas-relief (Pesce Delfino 2001)
- f) The body image was obtained by rubbing a bas-relief with pigments or acids (Nickell 1997).
- g) The body image was obtained by a modified carbon dust drawing transferred to the cloth by rubbing (Craig and Bresee 1994).
- h) The body image was obtained by exposing linen in a "darkened room" using chemical agents available in the Middle Ages (Allen 1998, Picknett and Prince 1994).
- i) The body image was obtained by exposing a linen cloth to sunlight with a glass plate containing an oil painted image on its surface (Wilson 2005).
- l) The body image was obtained by surface electrostatic discharges caused by an electric field, of seismic origin or directly generated by the enveloped Man (Scheuermann 1987, De Liso 2000, 2002, Lattarulo 2003, Fanti 2005, Fanti et al. Sept 2005).
- m) The body image is due to an energy source coming from the wrapped or enveloped Man, perhaps caused during the Resurrection (Lindner 2002, Rinaudo 1998, Jackson 1990, Moran 2002).

Although good experimental results have been obtained by a number of researchers, in the sense that, at first sight, the image, generally limited to the face, is similar to that of the TS Man, until now no experimental test has been able to reproduce all the characteristics found in the image impressed on the TS.

Some researchers interested in the TS scientific problems formed the ShroudScience Group on Yahoo to discuss these issues via the Internet. A first objective posed by them is that regarding the possible explanation of the body image formation. In order to deepen the discussion in accordance with the Scientific Method, all the scientists agreed to define a list of evidences of the TS upon which to base their further debate. This paper, *still in progress*, presents the list of evidences defined by the researchers, that are intended to be useful for future discussion.

2) LIST OF FACTS AND OBSERVATIONS

The list is subdivided in four different types of evidences:

- **Type A** refers to unquestionable observations made on the TS numbered as “An” where n is the evidence number;
- **Type B** refers to confirmed observations or conclusions based on a proof made in reference to TS studies and are numbered as “Bn”;
- **Type C** refers to facts or observations that were evidenced by some researchers but that are not universally accepted and are numbered as “Cn”;
- Assuming a scenario that the TS is actually the burial cloth of Jesus of Nazareth it makes sense, to include the Scriptures in this discussion, not on a theological level, but describing some things that might have an impact on the TS; for this reason **Type D** refers to correspondences with those described in the holy texts and are numbered as “Dn”.

2.1) Specific facts

The list of **Type A** facts refers to unquestionable observations made on the TS and they are at the basis of every hypothesis formulation in the sense that an hypothesis must be tested against all Type A facts and only if it is congruent with all of them, none excluded, can it be considered for further in depth study.

2.1a) CHEMICAL-PHYSICAL CHARACTERISTIC OF THE LINEN YARNS AND FIBERS

- A1) The yarn used to weave the Shroud was spun with a '**Z twist**.' (Raes 1974, Vial 1989, Curto 1976, Pastore 1988).
- A2) Direct microscopy showed that the **image color** resides only on the **topmost fibers** at the highest parts of the weave (Evans 1978; Pellicori 1981).
- A3) Phase-contrast photomicrographs show that there is a very thin coating on the outside of all superficial linen fibers on Shroud samples named "**Ghost**"; “Ghosts” are colored (carbohydrate) impurity layers pulled from a linen fiber by the adhesive of the sampling tape and they were found on background, light-scorch and image sticky tapes (Zugibe and Rogers 1978, Rogers 2002).
- A4) Body image **color** resides on the **thin impurity layer** of outer surfaces of the fibers (Zugibe 1978, Heller 1981; Rogers 2002).
- A5) According to M. Evans (1978) photomicrographs (ME-02, -08, -14, -16, -18, -20, -25, -29), the color of the image-areas has a discontinuous distribution along the yarn of the cloth: **striations** are evident. The image has a distinct preference for running along the individual fibers making up a yarn, coloring some but not others (Pellicori 1981, Schneider 2005). Fibers further from a flat surface, tangent to the fabric, are less colored, but a color concentration can be detected in correspondence to crevices where two or three yarns cross each other (ME-20) (Fanti 2005).
- A6) The cellulose of the **medullas** of the 10-20-micrometer-diameter fibers in image areas is **colorless** because the colored layer on image fibers can be stripped off, leaving colorless linen fibers (Heller 1981; Rogers 2002).
- A7) The **colored layers** in the adhesive have the same chemical properties as the **image color** on fibers (Rogers 2005).
- A8) The **crystal structure** of the cellulose of image fibers has **not visibly changed** with respect to that of the non-image fibers (scorches have) (Rogers 2002; Feller 1994).
- A9) The colored coating cannot be dissolved, bleached, or changed by standard chemical agents, but it can be **decolorized** by reduction with **diimide** (hydrazine/hydrogen peroxide in boiling pyridine); the residue from reduction is colorless linen fibers (Heller 1981, Rogers 2003).
- A10) The pyrolysis/ms data showed the presence of **polysaccharides of lower stability** than cellulose on the surface of linen fibers from the TS (Rogers 2004).

- A11) Photomicrographs and samples show that the image is a result of **concentrations of yellow to light brown fibers** (Pellicori 1981; Jumper 1984; McCrone and Skirius 1980; Schwalbe 1982; Rogers 2002).
- A12) The image-formation mechanism **did not char the blood** (Rogers 1978-1981).
- A13) The image formed at a relatively **low temperature** (Rogers 1978-1981).
- A14) The 1978 quantitative **x-ray-fluorescence-spectrometry analysis** detected significant uniform amounts of **calcium and strontium** concentrations (a normal impurity in calcium minerals), and **iron** in the Shroud (Morris 1980, Rogers 2003, Adler 1998).
- A15) Microchemical tests with iodine and pyrolysis/mass spectrometry detected the presence of **starch impurities** on the surfaces of linen fibers from the TS (Rogers 2002, 2004).
- A16) The **lignin** that can be seen at the wall thickenings and/or growth nodes of the linen fibers of the TS does **not** give the standard **test for vanillin** (Rogers 2002, 2005).
- A17) There is **no cementation** signs among the image fibers (Pellicori 1981).
- A18) **No painting pigments or media scorched** in image areas, or were rendered water soluble at the time of the AD 1532 fire (Rogers 1977-1978-1981/2002; Schwalbe 1982).
- A19) **No fluorescent pyrolysis products** were found in image areas (Rogers 2002).
- A20) After weaving, the TS yarns were **washed** with a very mild, natural material because of the presence of **flax wax** on the fibers and the specular reflectance of the non-image fibers (Rogers 2003).

2.1b) OPTICAL CHARACTERISTICS OF THE CLOTH

- A21) The cloth shows **bands** of slightly different colors of yarn that are best observed in ultraviolet photographs. For example between face and hair there are two non-colored bands that continue along the warp direction (Miller and Pellicori, 1981, Fanti 2003, Rogers 2002, 2005).
- A22) There is a **correspondence** (even if not complete) between cloth **bands** of slightly different colors of yarn of the front and **back surface** (G. Ghiberti 2002; Fanti 2003).
- A23) The colored fibers in non-image (background) areas show the **same type of superficial color** as body image fibers, their spectra are the same, and the cellulose in them is not colored (Gilbert 1980; Rogers 2002).
- A24) The body **image does not fluoresce** in the visible under ultraviolet illumination (Gilbert 1980, Pellicori 1981).
- A25) The **non-image** area **fluoresces** with a maximum at about 435 nanometers (Pellicori 1981).
- A26) A **redder fluorescence** can be observed around the **burn holes** from the AD 1532 fire (Pellicori 1981).
- A27) The cloth does **not** show any **phosphorescence** (Rogers 2005).
- A28) All the chemical and microscopic **properties** of **dorsal and ventral** image fibers are **identical** (Jumper 1984).
- A29) An emission **image** was clearly **visible in the 8-14 micrometers infrared** range (Accetta 1980).
- A30) **IR emission** of the image at a uniform **room temperature**, and in the **3-5-micrometer range** was **below** the instrument **sensitivity** (Accetta 1980).

2.1c) BODY IMAGE

- A31) The body image is **very faint**: reflected optical densities are typically less than 0.1 in the visible range (Jumper 1984; Schwalbe 1981).
- A32) The body image shows **no evidence of image saturation** (Jackson 1977, 1982, 1984).
- A33) The body image has a **resolution of 4,9±0,5 mm at the 5% MTF value** (for example the lips); the resolution of the bloodstains is at least ten times better (for example the scratches in the scourge wounds) (Jackson 1982, 1984; Moran 2002; Rogers 2003, Fanti 2004-MTF, Fanti Sept. 2005-MTF).
- A34) The body image **does not have well defined contours** (Jackson 1982, 1984; Moran 2002).
- A35) A **non-image area** is detectable among the **fingers** of the TS image (Fanti 2004).
- A36) There is a **darker spot** in correspondence of the palm of the Man's hand near the index finger (Accetta 2001, Antonacci 2000).
- A37) The **thumbs** are not visible in the hand image (Bucklin 1982, Ricci 1989).

- A38) In correspondence to the **middle of the nose** there is a **swelling** (Fanti 2004).
- A39) Detailed photographs and microscopic studies of the cloth in the nose image area show **scratches and dirt** (Bucklin 1982).
- A40) The **hair** on the frontal image show **high luminance levels** relatively to the face: for example the left hair is darker than the cheeks (Fanti 2004).
- A41) There is **no** evidence of **image between** the tops of the front and dorsal **heads** (Adler 1999; Moran 2002).
- A42) In the positive photograph of Durante (2000), the **luminance levels** of the front and back body images (face excluded) are **compatible** within an uncertainty of 5%; the front image is generally darker than the dorsal one (Moran 2002, Fanti 2005).
- A43) The image of the **dorsal side** of the body does **not penetrate the cloth** any more deeply than the image of the ventral side of the body ((Jumper 1984, Rogers 2005).
- A44) The **luminance level of the head** image in the positive photograph of Durante (2000) is 10% and more lower (**darker**) than that of the whole body image (Moran 2002).
- A45) The **image-forming mechanism** operated regardless of different body structures such as skin, hair, beard and perhaps nail (Antonacci 2000).
- A46) The **thermograms** did not show the lower **jaw** of the image (Rogers 2003), even if it is visible (Whanger 1998).
- A47) A body image **color** is visible on the **back surface** of the cloth in the same position of some anatomic details as for the body image of the frontal surface of the TS. The **hair** appears more easily to the naked eye (Ghiberti 2002) but also other details of face and perhaps hands appear by image enhancement (Maggiolo 2002/03, Fanti and Maggiolo 2004).
- A48) **No image** color is visible on the **back surface** in correspondence of the **dorsal** image (Ghiberti 2002; Maggiolo 2002/03, Fanti and Maggiolo 2004).
- A49) The nose image on the back surface of the TS presents the same extension of both nostrils, unlike the **frontal**, in which the **right nostril** is less evident (Fanti and Maggiolo 2004).
- A50) Image details corresponding to Face **grooves** are more faintly represented (e.g. eye sockets and skin around the nose), convex **'hills'** on the Face (e.g. eyeballs and nose tip) however are more clearly represented (Scheuermann 1983).
- A51) Although anatomical details are generally in close agreement with standard human-body measurements, some measurements made on the Shroud image, such as **hands, calves and torso, do not agree with anthropological standards** (Ercoline 1982; Simionato 1998/99; Fanti and Faraon 2000; Fanti and Marinelli 2001).
- A52) The body image shows **no** evidences of **putrefaction** signs, in particular around the lips. There is no evidence for tissue breakdown (formation of liquid decomposition products of a body) (Bucklin 1982; Moran 2002).
- A53) **No image formed under the blood stains** (Heller 1981; Schwalbe 1982; Brillante 2002).
- A54) The front image shows **hair that goes down to the shoulders** (Fanti and Faraon 2000).
- A55) The image of the TS Man, appears as if he was **scourged** (Bucklin 1982, Ricci 1989).
- A56) The image of the TS Man, appears as if he was **crucified**: it appears with nail holes and corresponding blood at the wrists and top of the feet (Bucklin 1982, Ricci 1989).
- A57) The image of the TS Man demonstrates no evidence of **maiming** or disfigurement (Bucklin 1982, Ricci 1989).

2.1d) BLOOD AND BODY FLUIDS

- A58) **Body fluids** other blood or serum than did not percolate into the cloth (Rogers 2003).
- A59) The blood or serum have migrated by **capillary imbibitions** from the "warp side" to the "weft side" of the TS and, depending on their abundance and consistency, they filled the mesh apertures (Fanti 2004).
- A60) There is a class of particles on the TS ranging in color from red to orange that test as blood derived residues. They test positively for the presence of protein, hemin, **bilirubin**, and albumin; give positive hemochromagen and cyanmethemoglobin responses; after chemical generation display the characteristic fluorescence of **porphyrins** (Adler 1999).

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- A61) The blood on the TS is **not denatured**. Therefore both the image-formation mechanism and the 1532 fire did not involve processes that would denature the blood (Rogers 2004).
- A62) The **blood** from the large flow on the back **darkened** (scorched) at an adjoining **scorch** (Rogers 1978).
- A63) The **red flecks** McCrone (1980, 2000) claimed were hematite had an **organic matrix** (Heller 1983, Rogers 2004).
- A64) Microscopic observation of **blood flecks** of sample 3EB showed specular reflection: **the blood went onto the surface as a liquid** (Rogers 1978).
- A65) **Blood** spots are much **more visible on the TS by transmitted light** than by reflected light; this implies that the blood saturated the cloth and it is not a superficial image as the body imager is (Rogers 1978).
- A66) Many **blood traces** visible on the frontal image are also visible **on the back** image in the **same position** (Fanti 2003).
- A67) **Blood stains** are well marked on the **reverse side**, although they are fainter than on the front side of TS (Fanti 2003, Whanger 2004).
- A68) Some human **blood stains** appear on and **outside of the body image** (left elbow) (Heller 1980, 1981, Baima Bollone 1981, 1982, Jackson, 1987, Carreira, 1998).
- A69) In correspondence to the **knees** on the dorsal image, there are scourge marks in correspondence to **lower luminance levels** of the body image (Fanti 2003).
- A70) The **blood** on the TS **does not fluoresce** in ultraviolet illumination (no porphyria and no fluorescent pigments) (Rogers 1978).
- A71) The **blood** on the TS can be removed with a **proteolytic enzyme** (Adler 1999).
- A72) **No smears** are evident in the blood traces (Bucklin 1982, Ricci 1989, Antonacci 2000).
- A73) **No potassium** signals could be found in any of the blood area data (Morris 1980).
- A74) In UV fluorescence the **scourge** marks appear with **dumbbell shapes** (Bucklin 1982, Ricci 1989).
- A75) In UV fluorescence the **scourges** are resolved into **fine scratches**: three, and in some cases four, parallel scratches can be distinguished (Bucklin 1982, Ricci 1989).
- A76) The blood stain corresponding to the right side of the **chest** 6th ribs shows **separation of blood** from a clearer liquid material (Bucklin 1982).
- A77) The **DNA** found in blood spots is badly **degraded**. (Rogers 2005).
- A78) **No broken fibers** were found under the blood clots (N. Svensson 2005).

2.1e) OTHER

- A79) **Earthy material** (limestone composed of aragonite with strontium and iron) was found on the **feet** of TS Man (Kohlbeck 1986, Nitowski 1986, 1998, Antonacci 2000). Earthy material was also found in correspondence with the **nose** and the **left knee** (Pellicori 1981).
- A80) Drops of **wax** were found (Maloney 1989).
- A81) Microscopic observation of the bridge of the **nose** showed discontinuous distribution of **light gold-colored fibers**. All were on the top of the yarn (Rogers 1978, 2004).
- A82) There is **no** observed microscopic, chemical, or spectroscopic evidence for the presence of any **dry powder** responsible for the body image on the TS (Adler 1999).
- A83) Some little **black spots** (diameter of 1-2 mm) appear out of the body image (for example near the head, between the hair and the water stain); they are also visible, in the same position, on the back surface of the TS (Maggiolo 2002/03, Fanti 2003, Rogers 2003).
- A84) Large **water stains** are visible on both sides of the cloth (Fanti 2004).
- A85) **Silver** traces were found around the burn holes in the scorch area of the TS (Heller 1983).
- A86) The white cloth used to cover the display board for the showing (1978) was fluorescent. Rudy Dichtel reported many intensely **fluorescent short fibers on the surface of the Shroud** (Rogers 2004).
- A87) **Aldehyde and carboxylic acid functional groups** were detected in the TS fibers (Adler 1981).

2.2) Confirmed observations

Type B refers to confirmed observations or conclusions based on a proof made in reference to the TS. Therefore these observations must also be used to test any new hypothesis.

2.2a) CHEMICAL-PHYSICAL CHARACTERISTIC OF THE LINEN YARNS AND FIBERS

- B1) The TS samples examined have **herringbone 3:1** twill weave (Vial 1989).
- B2) **Traditional dimensions** of the TS of 436 x 110 cm (Baima Bollone 1978) are changed after 2002 “restoration”: one side (the lower considering horizontal the body image, with the frontal side on the left) measured 437.7 cm in 2000 and 441.5 cm in 2002; the opposite side measured 434.5 in 2000 and 442.5 in 2002; its height of 112.5 and 113 cm respectively on the left and on the right in 2000 but 113.0 and 113.7 cm in 2002 (Ghiberti 2002). A measurement made in 1868 by Gastaldi (Baima Bollone 1978) reports the following dimensions: 410 x 140 cm (Scarpelli 1983).
- B3) The **thickness** of the cloth measured by Jackson with a micrometer is variable from 318 to 391 micrometers (Rogers 2004).
- B4) There appears to be more variation in the **diameter** of warp yarns than weft Rogers (1978).
- B5) The TS weave is **very tight** (Raes 1974, Rogers 1978, Vial 1989).
- B6) Although yarns and design of Raes sample look like the main part of the cloth, linen fibers from the **Raes sample** that was cut in 1973 are chemically **different** (from reflected spectroscopy and chemical analysis) (Adler 2000, Rogers 2002).
- B7) **Cotton** fibers were found in the Raes samples and they were identified as *Gossypium herbaceum*, a common Middle East variety (Raes 1974, 1991).
- B8) The **sewing** connecting the upper linen **band** of the TS is very particular and typical of very old manufacture (Flury Lemberg 2000, 2001).
- B9) Reflectance spectra, chemical tests, laser-microprobe Raman spectra, pyrolysis mass spectrometry, and x-ray fluorescence all show that the image is **not painted** with any of the expected, historically-documented pigments (Schwalbe 1982; Morris 1980; Heller 1981, Mottern 1979).
- B10) Chemical tests showed that there is **no protein painting medium** or protein-containing coating in image areas (Rogers 1978-1981; Heller 1981; Pellicori 1980, 1981; Gilbert 1980; Accetta 1980; Miller 1981).
- B11) The image fibers do **not** show any sign of **capillary** flow of a colored or reactive liquid (Evans 1978; Pellicori 1981).
- B12) Flakes of image color can be seen in other places where they fell off and stuck to the adhesive. The chemical **properties of the coatings** are the **same** as the image color on image fibers. All of the color is on the surfaces of the fibers (Rogers 2002; Heller 1981).
- B13) There are **no pigments** on the body image in a sufficient quantity to explain the presence of an image (Pellicori 1981).

2.2b) OPTICAL CHARACTERISTICS OF THE CLOTH

- B14) The TS linen has a **lustrous** finish (Rogers, 1978-1981).
- B15) If a fiber is colored, it is **uniformly colored** around its cylindrical surface (Adler 1996, 1999); relatively long fibers show variation in color from non-image to image area (Fanti 2004).
- B16) **Crease** below the **chin** of the image: on the frontal surface of the TS, the inside part of **crease** has a lighter color similar to the background, but it has darker margins similar to the image-color. On the back of the cloth, the same crease is darker in correspondence of the lighter color of the frontal surface and the margins are confused with the background: the darker margins are of the same straw-yellow color of the body image (Rogers 2004).
- B17) In the **ultraviolet** emission and absorption photographs the **background** cloth shows a light **greenish yellow** emission (Adler 2002).
- B18) Where one of the **image-yarn crosses over another**, there is often **no color** on the lower one (Heller 1983, Rogers 2005).

B19) The image of the **dorsal side** of the body shows fairly the **same color** density and distribution as the ventral (Jumper 1984).

B20) **IR photograph** of the face made by Judica Cordiglia, if compared with visible photographs of the face indicates the **low absorption near the IR** of the products of image formation (Judica Cordiglia 1974, Accetta 1980, Rogers 2003).

2.2c) *BODY IMAGE*

B21) Up to now, all the **attempts to reproduce a copy of the TS** similar in all the detected characteristics has **failed** (Carreira 1998, Fanti 2004).

B22) The **most of the prominent parts** in the vertical direction (nose, beard, sole, calf) of the body image **are marked** (Fanti 2003).

B23) The **hair** on the front image is **soft** and not matted as would be expected if it were soaked with a liquid (Fanti 2004).

B24) When their lengths are measured, the **dorsal image is longer** than the ventral image in a manner similar to the imprint on a sheet of a man having the head tilted forwards, his knees slightly bent, and his feet extended (Craig 2003; Cagnazzo 1997-98; Fanti 2000).

B25) The **frontal body image** (195 cm long) is **compatible**, within an uncertainty of ± 2 cm, with the **dorsal image** (202 m long) if it is supposed that the TS enveloped a corpse having the head tilted forward, the knees partially bent and the feet stretched forwards and downwards (Basso 2000).

B26) Based on cloth measurements (Baima Bollone 1978), the image corresponds to **a man 175 \pm 2 cm tall** (Simionato 1998-99; Faraon 1998-1999; Basso 2000).

B27) The body image has the **normal tones of light and dark reversed** with respect to a photograph, such that parts nearer to the cloth are darker (Jumper 1984, Craig 2004, Schneider 2004).

B28) The luminance distribution of both the frontal and dorsal images has been correlated to the clearances between a **three-dimensional** surface of the body and a covering cloth (Quidor 1913, Sullivan 1973, Gastineau 1974, Jackson 1977, 1982, 1984, Fanti 2001, Moran 2002).

B29) The luminance distribution of the body image can be correlated with a **highly directional mapping function** (Jackson 1977, 1982, 1984).

B30) The body image shows **non-directional light sources** in the sense that there are no shadows, cast shadows, highlights, and reflected lights in or on the body image (Moran 2002; Craig 2003).

B31) The absence of saturation implies that the **image formation did not “go to completion”**, i.e. it did not produce the maximum number of conjugated carbon-carbon double bonds (Rogers 2003, Gilbert 1980: fig. 8 and 10).

B32) In correspondence of image sections of cylindrical elements such as legs, the **luminance levels variation** approximates a **sinusoidal law** (Fanti 2004).

B33) In reference to a cloth wrapping a body, there is **no** evidence of body **image** formation at the **sides** of the body on both the frontal and dorsal TS images (Adler 1999; Moran 2002).

B34) The **Fourier transform** of the body image shows a nearly continuous spectrum in correspondence to the spatial frequencies up to 100 [1/m] (Fanti 1999; Maggiolo 2002/03).

B35) The body image indicates the **absence of brush strokes** (Lorre 1977).

B36) The frontal image, at least in correspondence to the head, is **doubly superficial** (Fanti and Maggiolo 2004).

B37) The **fingers** in the image appear to be **longer** than average for a man, but they are still within the normal range (Gaussian distribution) (Heller 1983, Whanger 2005).

B38) **Image distortions** of hands, calves and torso on the TS of are very close to those obtained by a man enveloped on a sheet (Ercoline 1982; Simionato 1998/99; Fanti and Faraon 2000; Fanti 2001).

B39) The very **high rigidity of the body** is evident on the back image especially in correspondence of the buttocks: the anatomical contours of the back image demonstrate minimal surface flattening (Bucklin 1982; Basso 2000).

B40) The image of the TS Man shows the effects (wounds) of many **pointed objects** (Bucklin 1982, Ricci 1989).

B41) The **tibio-femoral anthropometric index** of the image of the TS Man is 83% (Fanti 1999).

B42) **No broken bones** are evident on the body image (Bucklin 1982, Ricci 1989).

- B43) There is a **swelling** on the **face** over the right cheek (Bucklin 1982).
- B44) There is a slight **deviation of the nose** and at the tip of the nose is an area of discoloration (Bucklin 1982).
- B45) A **body image** is visible in areas of body-sheet **non-contact zones**, such as those between nose and cheek (Fanti 2004).

2.2d) *BLOOD AND BODY FLUIDS*

- B46) There is a first **type of blood** stain that corresponds to the blood **exudated from clotted wounds** and transferred to the cloth by being in contact with a wounded human body such as scourging and crown of thorns wounds or wrists wounds (Adler 1999).
- B47) There is a second **type of blood** stain that corresponds to the blood that directly **flowed** on the TS such as feet wounds or side wound with blood separation in a dense and a serous portion (Brillante 2002, Schneider 2004).
- B48) The UV photographs of single blood stains show a distinct **serum clot retraction ring** (Adler 1999).
- B49) The chemical and physical parameters of the **blood stains are different** than mineral compositions proposed by **artists** (Adler 1999).
- B50) The bloodstains observable on the back surface have been described as "**imbibed flows**" throughout the cloth (Ghiberti 2002).
- B51) Blood traces on the back surface of the TS are smaller in size when compared with the corresponding traces on the frontal side, showing that **blood was transposed** onto the cloth **touching the frontal** side of the TS (Fanti 2003).
- B52) The maintenance of the **red bright color** of the TS **blood** with time was observed, but the explanation of why the color is so red is not definitive (Brillante 2002).
- B53) There are **blood traces not consistent** with scalp hair traces soaked with blood in correspondence to the image of the **hair** on the front side (Lavoie 1983, Fanti 1999).
- B54) The **wrist wound position** can be referred to as the hand nail used for the crucifixion (Fanti and Marinelli 2003).
- B55) The **blood clots** were transposed to the linen fabric during **fibrinolysis** (Brillante 1983; Lavoie 1983). The process of fibrinolysis could cause clots to liquefy sufficiently for the blood to transfer to the cloth as a serous-laden liquid rather than a moist jelly-like substance (Craig 2004).
- B56) Some blood stains are comparable to transfers that would be expected if the arms were posed in **non horizontal position** (Lavoie 1983, 2003, Fanti 2005, Schwartz 2005).

2.2e) *OTHER*

- B57) The **limestone** found on the feet contains calcium in the form of **aragonite**. Similar characteristics were found on samples coming from Ecole Biblique tomb in Jerusalem (Levi-Setti 1985, Antonacci 2000).
- B58) It is **unknown** whether **Saponaria officinalis** can be detected on the Shroud (Rogers 2003; Jumper 1984; Gilbert 1980).
- B59) **Rust stains** due to thumb tacks were found on the sides of the TS (Faraon 1998/99, Schwartz 2003).
- B60) Characteristics of the TS face and right foot are close to those found on some **Byzantine coins** (gold-solidus) of the VII-XIII century A.D. (Moroni 1986).
- B61) Some **water stains** are older than the 1532 fire because they indicate a **different folding** of the TS (Guerreschi and Salcito 2002).

2.3) **Evidences to be confirmed**

Seeing things and not seeing things, is perhaps the biggest problem in legitimate Shroud research. "**I think I see**" and "I don't see" seems to be the underpinning of many "scientific" analyses. The body image on the Shroud was formed by some process. We don't know, for now, what that was,

nor the shape of the cloth, nor the environment where the body was positioned: we can only suppose what that might have been; we don't know many variables.

Our brain-eyes system may play tricks on the researcher. Because of a priori assumptions, it may be that he perceives things that conform to something searched for and conversely, he may fail to perceive images because of not knowing what various objects look like. Many of the images are below ordinary human perceptual threshold, therefore anything must be probed for documentable facts, including using image enhancement techniques.

Type C refers to facts that were evidenced by some researchers but that are not universally accepted; therefore they can help in formulating new hypotheses, they can not be used to test a new hypothesis.

2.3a) BODY IMAGE

C1) The chiaroscuro effect is caused by a different number of yellowed fibers per unit of surface, so that this is an image with '**areal**' **density** (Moran 2002, Fanti and Marinelli 2003).

C2) Body image characteristics can be referred to the hypothesized effect of a man became **mechanically transparent** that radiated a burst of energy (Jackson 1977, 1984, 1990).

C3) The TS face shows a sad but majestic **serenity** (Moroni 1997).

2.3b) OTHER

C4) **Pollen grains** relative to the zones of Palestine, Edessa, Constantinople and Europe were found (Frei 1979, 1983; Danin 1999).

C5) **Pollen grains** with **incrustations** soluble in water were found from the vacuumed samples taken from the back surface of the cloth (Riggi 2003).

C6) The wrapped or enveloped body was a **corpse** (Bucklin 1982, Lavoie 1983, Jackson 1998, Petrosillo 1988, Brillante 2002, Baima Bollone 2000, Fanti 2003, Zugibe 2005), but someone still states that the body was in a state of **coma** (Bonte 1992, Hoare 1994, Gruber 1998, Kuhnke 2004, Felzmann 2005).

C7) The human blood is of **AB group** (Baima Bollone 1981, 1982).

C8) The **radiocarbon dating** of 1988 states that the TS linen has an age of 1260-1390 (Damon et al. 1989).

C9) "Preliminary estimates of the kinetics constants for the loss of **vanillin** from lignin indicate a much older age for the cloth than the radiocarbon analyses" (Rogers 2005).

C10) There is the image of an identified **coin** (dilepton lituus) on the right eye (Filas 1982; Haralick 1983; Barbesino 1997).

C11) There is an image of another identifiable **coin** (Pilate lepton simpulum) over the **left eye** (Balossino 1997; Barbesino 1997).

C12) The TS is like a **funerary sheet** (Persili 1998).

C13) There are some **analogies** between the TS and the **Oviedo Sudarium**, including many congruent blood stains (Whanger 1996)".

C14) There are various **writings** around the Face (Marion 1998).

C15) There are many identified **floral images** on the TS, which indicate that the Shroud originated in the vicinity of Jerusalem in the spring of the year, and which have the appearance expected from corona discharge. Some images are consistent with the **fruits** of pistacia plants, which were used as burial spices (Danin, 1999; Whanger, 2000).

C16) **Human DNA** comes from Riggi's blood samples from the TS, this because three gene segments were cloned and studied (Garza Valdes 2001).

C17) Results from the **DNA** analysis, made from the TS blood at the University of Texas, S. Antonio, U.S.A., indicate that some genetic characteristics are relative to the **Semitic** race (for example hair) (Riggi 2003).

C18) The TS Man died because of an **infarct** followed by **hemopericardium** (Malantruccio 1992).

C19) Some **teeth** are visible on the image (Whanger 2000, Accetta 2001).

C20) The **skull** is visible on the TS (Whanger 2000).

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- C21) Images of the **bones** of the fingers, of the palms (metacarpals) and of the wrist are visible, and in particular a hidden thumb (Whanger 2000, Accetta 2001).
- C22) A **sponge** is visible on the TS (Whanger 2000).
- C24) A large **nail** with two crossed smaller nails are visible on the TS (Whanger 2000).
- C25) A **shaft** and head of spear are visible on the TS (Whanger 2000).
- C26) A **crown** of thorns with stalks and flowers is visible on the TS (Whanger 2000).
- C27) Some **bloodstains** such as those on the arms and the “reverse-3” on the forehead present a **discontinuity** in which a more attenuate region is evident (Jackson 1987, Schneider 2004).
- C28) Several wood tubules were found from an **oak** from Riggi’s samples (Garza Valdes 2001).
- C29) A **bioplastic coating** was found around the TS linen fibers (Garza Valdes 2001).
- C30) Traces of **saliva** are visible on the image (Scheuermann 1983).
- C31) Traces of **tears** may be visible on the body image under the right eye (Guerreschi 2000).
- C32) An **ecchymosis**, on the left shoulder-blade level, and a wound on the right shoulder that added to the wounds of the scourge are evident; in such areas the wounds caused by the scourge appear enlarged probably by the pressure of the **patibulum** (Ricci 1989).
- C33) Some **early paintings** of Jesus (before the VI century A.D.) in Rome have been produced independently from the TS but have a significant similarity to the image on the TS. If it is assumed that these paintings go back to people, who have known Jesus personally and knew therefore, how he has looked like. The significant similarities to the image on the TS indicates that both types of images go back to the same source: the historical Jesus (Felzmann 2003-2005).
- C34) **Natron** (sodium carbonate) was found in the dusts aspired from the back surface of the TS (Riggi 1982).
- C35) **Aloe and myrrh** were found by microscopic analysis (Baima Bollone 1983 and Nitowski 1986) but not by Heller (1983) and Rogers 2003).
- C36) The **scourge marks are part of the image** and primarily not caused from blood coming out of the wounds (Hoare 1994).
- C37) A **ponytail** is visible on the back image (Fanti and Marinelli 2001, fig. 12 B and C, Antonacci 2000, fig 3).
- C38) In the image of **the back of the head** some **blood stains** are partially **masked** (Scheuermann 1984).
- C39) Some blood stains are comparable to transfers that would be expected if a person was posed in the **vertical position** (Lavoie 1983, 2003).

2.3) Analogies between the TS Man and Christ, from the Old and the New Testament

It is hypothesized by many researchers that the TS is the burial cloth of Jesus of Nazareth. The following list presents passages in the Scriptures that have an impact on the TS. If these Scriptures are accepted as an historic document, **Type D** facts can be useful to verify the proposed hypotheses.

- D1) “And no sign shall be given to it except the sign of the prophet **Jonah**.” (Mat 16:4). “And all flesh shall see the salvation of God.” (Luk 3:6). “And I am with you always, even to the end of the age” (Mat 28:20). The TS shows a sign promised by Jesus: like Jonah “who remained for three days in the stomach of the big fish”, the Man of the TS remained for three days inside the sepulcher (Rodante 1987).
- D2) “A woman came to him with an alabaster jar of very expensive perfume, which she poured on his head as he was reclining at the table.” (Mat 26:7); “When she poured this **perfume** on my body, she did it to prepare me for burial.” (Mat 26:12). Less than 48 hours before his crucifixion, the hair of Jesus was anointed with a very valuable oil and this fact must be considered for an hypothesis about the TS image formation (Scheuermann 1984).
- D3) “Then Pilate took Jesus and **scourged Him**.” (Joh 19:1). “I offered my back to those who beat Me, /my cheeks to those who pulled out my beard; /I did not hide my face /from mocking and spitting” (Isa 50:6). The whole body of the MTS is cruelly scourged, except for the breast where, hitting, one

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- could cause death. The scourging was given like punishment apart, more abundant (120 strokes) than the normal (39 strokes) as a prelude to crucifixion (Zaninotto 1984).
- D4) “Then they **struck** Him on the head with a reed and spat on Him” (Mar 15:19). “And they struck Him with their hands” (Joh 19:3). The TS Man was hit on his face: for instance various tumefactions and the breakage of the nasal septum are evident (Fanti and Marinelli 1998).
- D5) “And the soldiers twisted a **crown of thorns** and put it on His head” (Joh 19:2). “When they had twisted a crown of thorns, they put it on His head” (Mat 27:29 etc). The TS Man was crowned with thorns. The head presents many wounds caused by sharp bodies (Fanti and Marinelli 1998).
- D6) “And He, **bearing His cross**, went out to... (the) Golgotha” (Joh 19:17). The TS Man presents on the shoulders excoriations imputable to the transport of the horizontal part of the cross (patibulum) (Ricci 1989).
- D7) “Now as they came out, they found a man of **Cyrene**, Simon by name. Him they compelled to bear His cross” (Mat 27:32). The TS Man fell repeatedly to the ground; this is demonstrated by the dust particles on the nose and on the left knee. Likely he was helped in the transport of the cross (Fanti and Marinelli 1998).
- D8) “My throat is **dry**” (Psa 69:3), “And for my thirst they gave me vinegar to drink” (Psa 69:21). From the forensic medicine analysis it results that the MTS died dehydrated (Intrigillo 1998).
- D9) “Where (on the Golgotha) they **crucified** Him” (Joh 19:17). “They pierced My hands and My feet. I can count all My bones” (Psa 22:16-17) “You have taken by lawless hands, have crucified, and put to death” (Act 2:23). The TS Man too was crucified (Fanti and Marinelli 1998).
- D10) “Reproach has **broken my heart**” (Psa 69,20). “And Jesus **cried out** again with a loud voice, and yielded up His spirit” (Mat 27:50) “Because for Your sake I have borne reproach; Shame has covered my face” (Psa 69:8). “My heart is like wax; It has melted within Me” (Psa 22:14). The hemopericardium, diagnosed to the TS Man like consequence of the infarct, causes a violent dilatation of the pericardic pleura with consequent shooting pain from the back breast-bone and immediate death (Malantruccio 1992).
- D11) “And saw that He was already dead, they **did not break His legs**” (Joh 19:33). “Nor shall you break one of its bones” (Exo 12,46). Contrary to many Roman crucifixions, they didn’t break the TS Man legs (Fanti and Marinelli 1998).
- D12) “But one of the soldiers **pierced His side** with a spear” (Joh 19:34), “But He was wounded for our transgressions” (Isa 53,5). “then they will look on Me whom they pierced” (Zec 12:10). The TS Man too was pierced in the side after his death (Zaninotto 1989).
- D13) “And immediately **blood and water came out**” (Joh 19:34). “Flowing from under the threshold of the temple toward the east, for the front of the temple faced east” (Eze 47:1). “This is He who came by water and blood Jesus Christ; not only by water, but by water and blood” (1Joh 5:6). The TS Man also presents a blood and serum flow (Malantruccio 1992).
- D14) “And Nicodemus, who at first came to Jesus by night, also came, bringing a **mixture of myrrh and aloes**, about a hundred pounds” (Joh 19:39). “Then they took the body of Jesus, and bound it in strips of linen with the spices, as the custom of the Jews is to bury” (Joh 19:40). Some researchers state that the TS body was buried with aromatics such as aloe and myrrh because they found their traces on the cloth (Baima Bollone 1983).
- D15) “When Joseph had taken the body, he **wrapped it in a clean linen cloth** (or shroud), and laid it in his new tomb” (Mat 27:59-60). The TS Man too was enveloped or wrapped in a new and expensive sheet, bought by a wealthy person (Fanti and Marinelli 1998).
- D16) “**Nor will You allow** Your Holy One to see **corruption**” (Act 2:27). “For You will not leave my soul in Sheol, Nor will You allow Your Holy One to see corruption” (Psa 16:10). The TS doesn’t show signs of putrefaction (Fanti and Marinelli 1998).
- D17) “You shall let **none of it (the Lamb) remain** until morning, and what remains of it until morning you shall **burn with fire**. It is the Lord’s Passover” (Exo 12:10). Some researcher states that the TS presents a double sign: the disappearance and the burning, if one refers to the radiant hypothesis (Rinaudo 1998).

- D18) “For as **lightning** that comes from the east is visible even in the west, so will be the coming of the Son of Man.” (Mt 24,27); “For the Son of Man in his day will be like the lightning, which flashes and lights up the sky from one end to the other.” (Lk 17,24). The German theologian G. Schwarz (1986) rectifies the Bible by translation into the Aramaic language. It seems, in doing so, he found the Shroud image forming process in the Bible independent on the TS: “As a flash in lightning and shining: so I will exist in my day!” (“my day” = the day of Jesus Resurrection) (Scheuermann 1987).
- D19) “There was a violent **earthquake**, for an angel of the Lord came down from heaven and, going to the tomb, rolled back the stone and sat on it.” (Matthew 28,2). Someone hypothesise the presence of an earthquake as a cause of the body image formation (Judica Cordiglia 1986, DeLiso 2002, Lattarulo 2003).
- D20) “Then the other disciple, who came to the tomb first, went in also; and **he saw and believed**. For as yet they did not know the Scripture, that He must rise again from the dead” (Joh 20:8-9). “David, foreseeing this, spoke concerning the resurrection of the Christ” (Act 2:31). One hypothesis states that the TS Man became mechanically transparent with respect to the sheet and shed a flash of energy that would be the cause of the body image formation (Jackson 1990). Perhaps the particular shape of the TS seen by John induced him to believe in Christ’s Resurrection.
- D21) “After that, **He appeared to more than five hundred of the brothers** at the same time, most of whom are still living, though some have fallen asleep.” (1. Cor. 15:6) Paul has written this letter in the year 53-55. The time is too short (eyewitnesses) that all this might be an invention without historical nucleus (Felzmann 2003).

4) CONCLUSIONS

The first goal posed by the researches of ShroudScience Group on Yahoo!, in order to better understand the TS, has been reached: a list of evidences of the TS upon which to base their further debate on the body image formation problem has been defined, even if the work, is still in progress. Obviously some open questions will be easier to solve if the Turin officials become open to sharing new results and those obtained in 2002 to the Shroud Science Group and to any credible researcher interested the study about the most important relic of Christianity.

In consideration of space limitations, the facts have been stated in very simplistic terms, but the rich bibliography enclosed will allow the reader to go far more in depth in reference to the argument of interest.

Many hypotheses have been presented and some natural hypotheses are under test, but hypotheses involving the Resurrection of Jesus of Nazareth can not be rejected. Among them there are hypotheses correlated to an energy source coming from the enveloped or wrapped Man, other correlated to surface electrostatic discharges caused by an electric field or other correlated to natural chemical reactions also helped by the body fluids transferred to the cloth, but none, scientifically testable, simultaneously satisfies all the facts detected on the Shroud here reported. On the other hand other hypotheses such as that of Jackson (1990) seems to satisfy almost all the presented facts, but it is not scientifically testable because it bases itself on a non-scientific fact: the mechanically-transparent Man.

Next goal of ShroudScience Group on Yahoo! will be the presentation of all the possible hypotheses about the body image formation in a detailed form in order to test them against the facts reported in this paper. Each hypothesis should have a title in reference to the technique involved in the TS formation, not only considering the body image formation; the author’s name who first proposed the hypothesis coupled with the researcher’s name who presents it; a detailed technique description for the formation of both the body image and the blood stains; possible correlation or interferences with the formation of other stains such as water; comments and bibliographic references.

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