Internal selvedge in starched and dyed temple mantle – No invisible repair in Turin Shroud – No Maillard reaction

Verwijderd: peak shift

1. Introduction

In 1988, the radiocarbon dating of a sample from the Shroud of Turin yielded a 13-14th century date (1260-1390). The scientists involved in the radiocarbon dating announced that the Shroud was medieval. However, many other evidences about the Shroud had already indicated that it couldn't have been produced in the 13-14th century, and that it is much older. The announcement of a medieval date opened the doors for further studies that countered the radiocarbon dating. During these new researches, many hypotheses were established to help explain the discrepancy. One hypothesis, based on the unexpected presence of cotton and a gum crust in the carbon dating area, says that the carbon dating sample was chemically anomalous in comparison with the main part of the Shroud and that this sample contained a 16th -century repair.

In this article I will question both this "anomaly" and that there was a repair, and propose another explanation for the research results: the Turin Shroud, already identified as a Pharisaic priest's temple mantle in other ways,[1] has an internal cotton-linen selvedge at the Pharisaic seam in the sample area; the mantle was also starched and slightly dyed with Madder at manufacture, to strengthen and give a uniform color to the temple garment, that – as the Talmud commentary Maimonides says of any temple garment – should look new and was not allowed to be washed. Later, when the Shroud was surviving the fire of 1532 AD, in light scorch areas, such as the radiocarbon dating area, the starch coating was roasted to a starch gum coating.

1.1. Dyed temple mantle with Pharisaic enlarged border

The explanation of the research results of the carbondating sample area probably is that it belonged to an internal selvedge, woven into the cloth with warp threads spun of a cotton-linen blend, where the Pharisaic seam of the temple mantle was going to be applied – it was the custom of Pharisees to "enlarge the borders of their garments" (Mt 23,5 KJ21). Linen is easily creased especially near the edges of a cloth. At creases and folds it breaks more easily than cotton.[2] The internal seam near the longitudinal edge of the cloth would consist of two folded pieces, sewn together, and would be stronger if cotton was in the warp. Also in the long outer edges of the cloth such a cotton blended warp may have been applied in the observed selvedges. In the short edges of the cloth, where the rolled hems were going to be applied, also the weft threads may have been of a cotton-linen blend.

In the first century the linen fibers, or, for the selvedges and seam and hems, the cotton and linen fibers, were hand spun into a thread on a spindle whorl, and when a spindle was full, the batch of thread was taken off and bleached separately.[3] Each batch thus was slightly differently bleached than the other batches, and would have a slightly different color. For weaving, the warp threads were probably strengthened and lubricated by wiping them with a cooked starch paste.[4] During weaving also the weft threads, by being woven between and combed along the warp threads, would get lubricated with this starch paste. After weaving, most of the stiff starch coating would be washed out of the cloth with warm water, leaving only a thin starch film around the threads.[5]

Some Madder dye – a reddish-yellow fugitive plant dye – may have been in the last water, in order to give the differently bleached batches of the therefore banded looking linen cloth a more uniform color.

A temple garment was a uniform which would never be washed and should look new, for no sign of poverty was allowed in the temple: any dirty temple garment or worn-out temple garment that was torn in many places would simply be replaced by a brand new one, and would be cut into pieces and used for wicks for the lamps of the temple.[6] So, the cotton in the selvedges of the seam, long edges and hems, would strengthen the cloth against wear and tear and would increase the life of the garment, and the remaining starch film, containing the dye, would never get washed out. The Madder dye was a very fugitive one and would eventually discolor and uncover the banded appearance of the linen again, but the garment would get dirty and be replaced before the discoloring of the Madder would appear. In the case of the Shroud, the aging of the cloth gave all threads a more sepia color.

Some parts of the high priest's clothes had to be made of "shesh" (e.g. Ex 28,4-5.8). The Hebrew word "shesh" means 'something bleached, whitened'[7] and "is applicable to both linen and cotton"[8], and even to silk, alabaster and marble.[9] In Greek, both linen and cotton were

called *byssus* in the first century[10]. The word *byssus* is a corruption of the Hebrew word 'buts'[11], which means "whiteness"[12].
Le 19,19 says " Ye shall keep my statutes. Thou shalt not let thy cattle gender with a diverse kind: thou shalt not sow thy field with mingled seed: neither shall a garment mingled of linen and woollen ('sha'atnez') come upon thee" (KJV). Strong's Hebrew concordance says of the word 'sha'atnez' (that is translated as 'of linen and woolen'): "Probably of foreign derivation; *linsey woolsey*, that is, cloth of linen and wool carded and spun together: - garment of divers sorts, linen and woollen." De 22,11 says "Do not wear clothes of wool and linen woven together" (NIV), "Thou shalt not wear a garment of divers sorts ('sha'atnez), *as* of woollen and linen ('pishteh') together" (AV). Here the AV-italized word '*as*' is only in the English translation, not in the Hebrew text. This verse indeed seems to define the forbidden mixture 'sha'atnez' as a mixture of wool and flax ('pishteh' = flax, linen). It seems linen-cotton was not a forbidden mixture, only linen-wool. Nevertheless, even to this prohibition of linen-wool there was one exception: during sacrificial service the priests in the temple were allowed to wear 'sha'atnez'[13]: the girdle of the priests contained wool and linen.[14]

1.2. Scorched starch: starch gum crust

After the temple mantle had been used as Jesus' Shroud,[15] it was kept as a relic. The fire in 1532 AD in Chambery, where the Shroud was kept then, made burn holes and scorch areas in the Shroud. The carbon-dating area belonged to a scorch area,[16] where the heat and lack of oxygen during the fire probably roasted the starch coating of the threads into a coating of yellow-brown starch gum – also called British gum –, consisting of pyro-dextrins.[17]
The observed gum coating on Raes threads was much thicker on cotton fibers than on linen fibers.[18] As the main Shroud showed only traces of cotton and mainly consists of linen fibers, these linen fibers' starch coating – also where it was roasted to starch gum in scorch areas – would have been much less visible than on the cotton fibers in the Raes area. Even the gum coating on the Raes threads "can easily be missed when normal procedures are followed" and "can be completely invisible on a normally prepared slide".[19]

2. Chemically anomalous?

2.1. Cotton

2.1.1. Raes threads – cotton spun in: yes

Raes: ancient cotton spun together with linen

In 1973 a small irregular triangle was cut from the ventral left corner of the Shroud, which held the side seam, but where the side strip was already missing (at the so-called 'missing corner'). Documents held by the Holy Shroud Guild confirm that only one piece of cloth was cut, and that the dimensions of this irregular triangle were about 40 x 13 mm.[20] This one triangle of cloth was given to Raes and he investigated it. In his report he mentioned two pieces and the sewing thread which held these pieces together. The dimensions he gave for Piece 1 are 40 x 13 mm, and for Piece 2 40 x 10 mm. The sewing thread was a 2-ply linen yarn with a S-twist.[21]
He reported that "in some of the preparations from the warp as well as from the weft of Piece 1, traces of cotton fibers were observed"[22]. The cotton fibers he observed showed about 8 reversals per cm, corresponding to the cotton type Gossypium herbaceum, an ancient Egyptian cotton.[23] Raes didn't report the observation of any cotton in Piece 2.[24] Textile expert Tyrer published a photograph of the observe side of the original Raes sample and wrote: "Raes also describes the sample he obtained as carrying a selvedge. The photograph of Raes' triangular sample does show a narrow warpway band of different structure on the longest side."[25]
In a 1980 letter, owned and temporarily published by the Holy Shroud Guild in 2011, Otterbein writes to Sox on the Raes sample and says that the the side strip was thought to be an integral part of the Shroud (not added at a later date) though woven diffently due to some anomaly in the operation of the loom.

As only one piece of cloth was cut from the Shroud in 1973, and Raes reported two pieces and the sewing thread that had held the two pieces together, he apparently unstitched the seam[26] which joined the two separate pieces (side strip and main Shroud).[27] As both Raes pieces (1 ánd 2) are 40 mm long, the seam in the original triangle of about 40 x 13 mm was about 40 mm long. As the original piece was only 13 mm wide and the width of Piece 1 is 13 mm and the width of Piece 2 is 10 mm, the unstitching of the 4-5 mm wide seam[28] and its unfolding, added about 10 mm to the sum of the widths. Before unstitching and unfolding the seam also the hem must have been unrolled, for the hem was applied after the seam, as the hem is rolled over the seam (see the photograph published by Heimburger[29], and see a scetch of it in fig. 1 below)
Raes "called the sample on the right of the seam Part I, and that on the left Part II" – here right is referring to the side of the main part of Shroud, and left is referring to side of the side strip.[30]

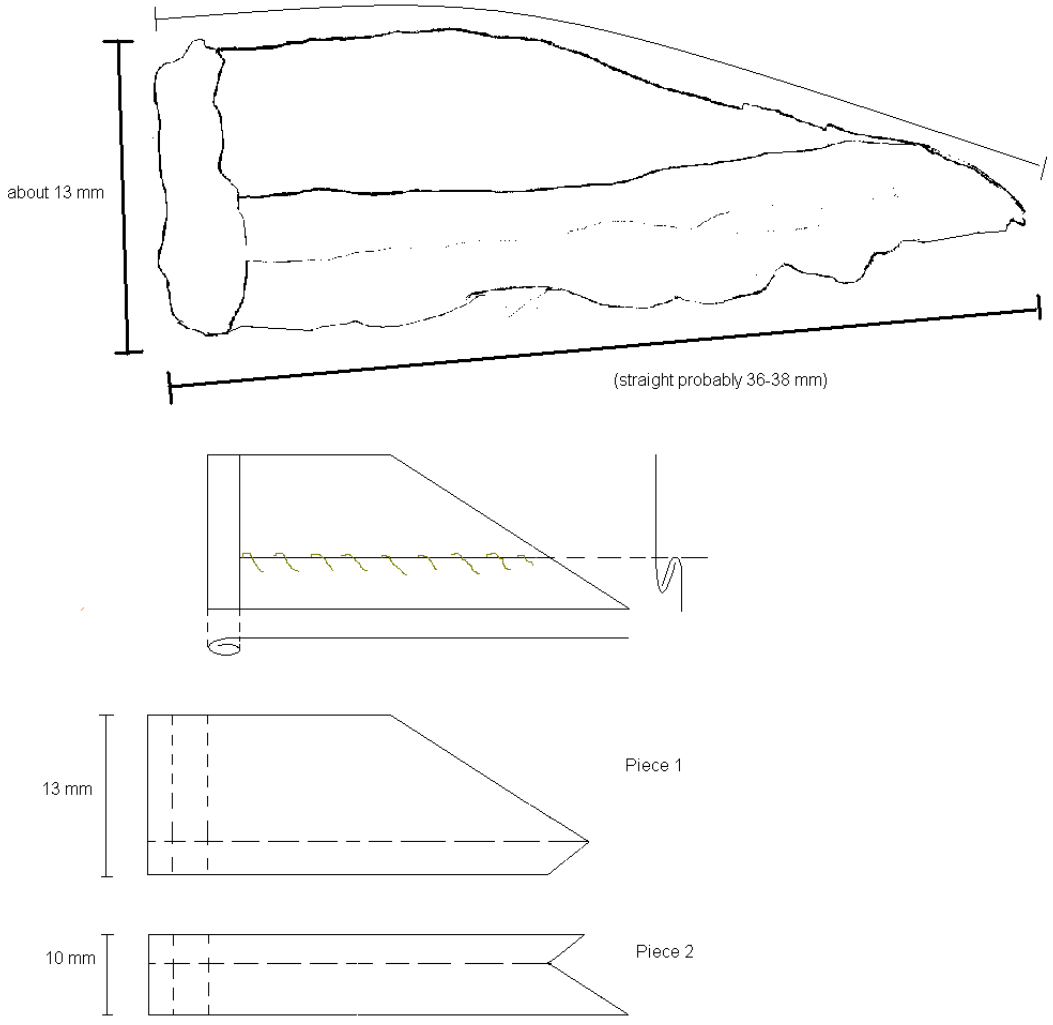

Fig. 1 Scetch of Raes sample, Piece 1 and Piece 2

Hall: yellow old cotton in C14-sample
In 1988 a carbon dating sample was cut from the same corner of the Shroud as from which the Raes sample had been cut in 1973.[31] In the article on the results of the carbon dating of the Shroud sample, in the thanking section, reference is given to "identifying the cotton found on the shroud sample", i.e. the subsample investigated in the laboratory of Oxford.[32]
"In "Textile Horizons" one reads "Prof. Hall noticed two or three fibers which looked out of place. The strange fibers, looking like human hairs, were sent to Derby. Under the 200 x

microscope the fibers were identified as cotton. The cotton is a fine dark yellow strand, possibly of Egyptian origin and quite old. Unfortunately it is impossible to say how it ended up in the Shroud, which is basically made from linen. It may have been used for repairs at some time in the past or simply became bound in when the fabric was woven …".[33]

Rogers: 10-20% ancient cotton spun together with linen

"I received 14 yarn segments from the Raes sample from Professor Luigi Gonella (Department of Physics, Turin Polytechnic University) on 14 October 1979. I now have these samples numbered, photographed, and identified as the "Raes threads." There was no indication which segments came from Part I and which, if any, from Part II"[34].

Rogers found old cotton, with a yellow-brown coating and spun with the linen, in the Raes threads R5 (warp), R7 (weft) and R14 (warp or weft).[35] "R7 is definitely some kind of blended thread: cotton (10%-20%)/ linen (80-90%). There is more cotton in the outer part than in the core. Both kinds of fibers have been spun together to obtain the thread."[36] "Raes # 7 is about 10 mm in length".[37] Rogers said of Raes thread R14: "When the cotton fiber was drawn out of the thread, it showed reversals about 1.2-mm apart."[38] So, this would match the roughly 8 reversals per cm of the ancient type Gossypium herbaceaum, observed by Raes.

Rogers also found several cotton fibers in warp threads from the radiocarbon area.[39] Heimburger wrote: "Second, Rogers clearly stated that he found also many cotton fibers in his radiocarbon threads. … However, it is likely that these threads came in fact from the so-called "Riserva". When the strip was cut in 1988, it was divided in 2 parts: one part for the laboratories (this part was then divided in 4 subsamples) and the other part (the "Riserva") that was kept in Turin. I had access to the private notes of Rogers about the radiocarbon threads he got. One can read for example: "*Radiocarbon warp* (dated 2/3/04): *several cotton fibers are visible*" or "*Two cotton fibers visible (..), there is cotton in the radiocarbon warp (…), there is* ***plenty*** [emphasis mine]*of cotton in the warp*"."[40]

Villarreal (LANL): cotton and/or old linen?

The Raes threads R1, R7 and R14 were examined at the Los Alamos National Laboratory, and only characteristics of cotton were found. The XPS-spectra showed that both ends of the thread R1 were chemically similar, and they looked like the spectrum of cotton without linen contamination. Elemental analysis showed only some moderate differences between both ends of R1. The FTIR results of threads R7 and R14 also were charactaristic of cotton, without linen impurities. It must be noted, however, that also the FTIR results of the so-called Tama4 thread, which was "probably from the main Shroud" was comparable with cotton, and doensn't have the linen characteristic. Villarreal said they had "no actual Shroud linen standard available".[41]

Jull and Freer: cotton in carbon-dating sample

A small piece of cloth that was left after the rabiocarbon dating in Arizona, was examined through the microscope by Jull and Freer. They found three cotton fibers.[42]

2.1.2. Main Shroud – cotton spun in: yes, traces

Cotton was found at several sticky tape samples taken from the main Shroud by STURP in 1978. McCrone found cotton at sticky tape 3AF from the middle finger[43]. Nitowski found cotton at sticky tape 9CF from the watermark margin above the head ("burned flax with cotton"), and at sticky tape 6DF from the image above the abdomen ("particle cluster with cotton and flax fiber").[44] Others say that at sample 3AF, 1HB, 6AF, 3BF, and 3EF no cotton could be found.[45] Heller (STURP) reported that on McCrone's slides with sticky-tapes there was a lot of debris present, "both modern and ancient linen of different shades, tint, and degrees of corrosion, cotton, silk, wool, animal hairs, …".[46] Rogers (STURP) reported that no cotton was found on the sample from the back of the ankle.[47] Later Rogers didn't look for cotton on the main Shroud sticky tapes, "because there was too little cotton of any kind on Shroud samples", and reported that the STURP scientists had used white cotton gloves during the STURP studies and that "they could have been responsible for the traces of modern cotton

found on a few Shroud sampling tapes."[48]
Villarreal showed photomicrographs of a sticky tape sample, on which a yellow and a white twisted flat fiber was seen, and he also showed some reddish "flattened" fibers.[49] There were also cotton fibers present in the dusts vacuumed from the Shroud.[50]

Fanti and Heimburger: 2,1% cotton near C-14 area

A certain weft thread, "coming from the 1988/C-14 area named F15001", "came from the edge of the cloth in proximity of the "Riserva sample", at the border of the C14 sampling area."[51]. The thread was examined by Fanti. Through the microscope he counted the linen fibers and the cotton fibers of the end of the thread, and found that 2,1 % of the 188 fibers of the thread were cotton. The cotton fibers were present inside the thread, but had a mean width "at least two times smaller than that typical of 0.016 mm: this leads to think that the linen threads were woven in an ambient where also cotton threads were prepared and some fiber smaller than the normal were present in the ambient air".[52]

2.1.3. Comparison: both have cotton spun in

Traces of ancient Near Eastern cotton were observed on warp and weft threads of Raes Piece 1, no traces of cotton were seen on threads from Raes Piece 2. After dissection, 10-20% of ancient cotton was found spun in Raes threads R5 (warp) and R7 (weft) and plenty of cotton in at least some warp threads of the C14-Riserva. After dissection, 2% cotton was found spun in in (weft) thread F15001 from the edge of the cloth near the C14-Riserva, and only traces of cotton were seen on the sticky-tapes from the main Shroud. A possible configuration of these data is scetched in figure 2.

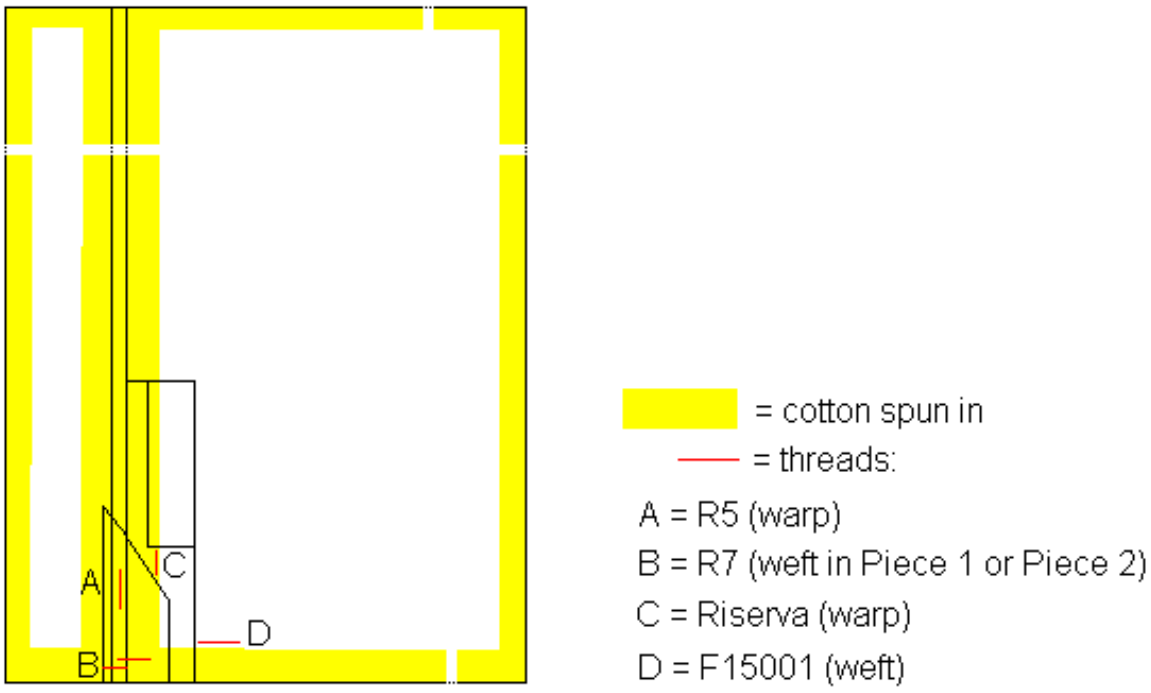

Fig. 2 Rectangular scetch of irregular samples and threads and cotton-linen sections

Here it must be noted that absence of evidence of cotton in Raes Piece 2, doesn't mean evidence of absence. Raes reported to have observed only "traces" of cotton in Piece 1, although Rogers, after dissecting a Raes thread, found 10-20% of cotton, especially in the surface of the thread. The reason for this difference probably is that, as Marino and Prior said: "The simple observation with a binocular magnifying glass (or even a microscope) of the threads does not allow the finding of cotton among linen fibers. ONLY the separation of many individual fibers makes it possible to recognize the nature of the fibers."[53] Also Heimburger said on Raes thread R7: "It is impossible to

see the cotton on the whole thight thread "as received", even with polarized light microscopy: it is necessary to separate many fibers".[54] In fact, Raes may not even have been looking for cotton on Piece 1 or 2, and only incidentally have observed a cotton fiber protruding from the surface of a thread of Piece 1.[55] And because the cotton-containing Raes thread R7 was a weft thread about 10 mm long, it may have belonged to Piece 1 or to Piece 2, which was 40 mm (warp) x 10 mm (weft). And as the seam joined two pieces that originally had been continuous,[56] also weft thread R7 most probably had been continuous in Piece 1 and 2.
Rogers said about the adhesive of the sticky-tapes: "The two indices of cotton are close to that of the adhesive. Birefringence is first-order white. The index of linen across the fiber is appreciably lower than that of the adhesive."[57] So, cotton is nearly invisible on sticky tapes, and are easily missed by scientists who aren't looking for it. Heimburger said "The important point is that cotton was found by Raes and Rogers in the depth of the Raes sample (and the radiocarbon threads by Rogers) and was not found by Rogers elsewhere on the 1978 samples of the Shroud surface. The question which one can legitimately ask is the value of the conclusions coming from the comparison between surface samples and a thick sample (Raes)."[58]
So, the conclusion is that the cotton-linen blend of the Raes warp threads may have been continuous all along the length of the Shroud, and that the cotton-linen blend of the Raes weft threads may have been continuous all along the width of the Shroud. The only objective quantitative difference in cotton content in the threads was detected between warp threads of the Raes corner (10-20 % deliberately spun in) and a weft thread of the main Shroud near the Riserva (2 % contamination spun in). This is consistent with the presence of a narrow cotton-containing selvedge in the warp of the Raes corner, along the seam, and in the weft along the hems.

2.2. Starch

2.2.1. Main Shroud – 'red' starch: yes

When describing how a linen cloth could have been manufactered before the last crusade (AD 1291), Rogers wrote, "The warp thread was protected with starch during the weaving process, making the cloth stiff."[59] This starch was a gelatinous paste of cooked starch. As the weft thread was woven between the warp threads and combed down along the warp threads, also the weft threads will have been more or less coated with this cooked starch. The starch was meant as a lubricant, as linen threads easily break during weaving.[60]
Rogers also wrote: "When tested with iodine, normal soluble starch turns blue. Starch that is soluble only in hot water turns red. The higher-molecular-weight, hot-water-soluble starch is the last to wash out of a cloth."[61] The starch component that turns blue with iodine is amylose (and apparently is washed out with cold water); the starch component that turns red with iodine is amylopectin (and apparently is only soluble in hot water).[62] Both starch components are polysaccharides made of glucose units, but amylose is a single long chain of glucose units, and is lower in molecular weight than amylopectine, which consists of very many shorter branched chains of glucose units.
Elsewhere Rogers wrote, in 2001: "We expected to find starch on the Shroud, so we did not specifically look for it. That was an unfortunate oversight. Starch is a very complex carbohydrate, and not all sources give exactly the same material. The starch might have given us information on is [sic] source and the provenance of the cloth. Starch consists of two main polysaccharides (shorter chains with the same general structure as cellulose). Starch "toasts" much more easily than cellulose, giving the familiar colors from yellow through brown. One of its components, amylose, dissolves in water to give a clear blue color with iodine. The other dissolves only in hot water to form a paste, and it gives a violet color with iodine. Some of it should have remained after the stiff cloth was washed immediately after manufacture. When we were testing for sulfoproteins in blood areas with an iodine-azide reagent (it bubbles vigorously when sulfur is present), we got a reddish background. The color should have suggested some polysaccharide impurities to us. We should have tested for starch."[63]. In a later work, of 2002, he wrote: "Microchemical spot tests with aqueous iodine indicated the presence of some starch fractions on Shroud fibers"[64] and

"Microchemical tests with iodine indicated the presence of some starch fractions on the cloth. … The hypothesis on carbohydrate impurities is supported by observations of traces of some starch fractions on image fibers."[65] Rogers' book of 2008 reads: "Two important claims were made by Walter McCrone. ... Walter also stated that he had found wheat starch on the Shroud. We confirmed this by microchemical testing with aqueous iodine, supporting an hypothesis that the cloth had been made by ancient methods."[66] Fact A15 of the 2005 list of evidences on the Shroud says: "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)."[67] Here, the reference "Rogers … 2004" refers to a Shroud Science Group Communication. In 2004 Rogers also wrote: "A search for carbohydrate impurities on the Shroud confirmed McCrone's detection of some starch fractions."[68] Also Kohlbeck had detected starch, before November 1986, perhaps also on sticky-tape sample 6BF (lance wound area).[69]

Verwijderd: namely

So, the starch that was found on both image fibers and one or more fibers from blood areas, and that seems to have remained on the Shroud after weaving and washing, turned red with iodine. This means that there was only amylopectin or completely retrograded amylose[70] and no single-helix amylose, and that the Shroud had been washed in water of a temperature that did not dissolve/suspend all higher-molecular-weight starch.

Heller, on the other hand, reported in 1983: "So he [Adler] proceeded to test image fibrils for phenols, riboflavin, steroids, indoles, lignin, starch, pyrroles, creatinine, urea derivatives, uric acid, and nitro derivatives. They were all negative."[71] "It was time to get down to what I considered the serious testing for straw-yellow fibrils so that we could determine the nature of the color. … Now we had arrived at the part we were reasonably sure would answer the question "What chemical made the straw-yellow images?"… We made some specific tests for certain classes of organic compounds – phenols, flavenoids, steroids, indoles, lignins, porphyrins, pyrroles, nitroderivatives, and Saponaria extract (soapwort), to mention but a few."[72] Here Adler and Heller used the iodine test[73] on image fibrils[74] that were probably completely covered with the dehydratized and oxidized carbohydrates constituting the image color.[75] Where the image formation process reached any starch, it probably dehydratized and oxidized this starch, perhaps about just as easily as it would dehydratize and oxidize the hemicellulose of the linen, and even more easily then it would dehydratize and oxidize the cellulose of the linen.[76] Heller and Adler wrote "It should be noted that although all of the other organic tests [beside the aldehyde and carboxyl tests] are negative, this does not preclude the possibility that some of these substances may have resided on the cloth in the past and been "lost" over time through oxidation, degradation, etc. … This simply demonstrates that positive tests in some cases would have been more meaningful than the negative tests."[77] The "traces of some starch fractions" found on image fibers, as reported by Rogers,[78] may have remained on the not-colored parts in the color variation along the length of long image fibers.[79] That Heller and Adler found no starch on image fibers would be consistent with an image fiber's uniform coloration around its cylindrical surface.[80]

Rogers wrote in 2002 about the scientific investigations performed on the 1978 Shroud samples and a Raes thread: "Many of the pyrolysis fragments observed by pyrolysis-mass-spectometry would be the same products of thermal degradation whether they came from cellulose, hexose sugars, or starches; i.e., a starch impurity would not have been detected. UV and visible spectrometry would not see any differences among the carbohydrates. The -OH vibrational states of all of the carbohydrates and water are very broad and intense, and IR spectrometry could not distinguish among them. Laser-microprobe Raman is similar to IR. We were not looking for trace carbohydrate impurities, we were looking for painting-type impurities on the cloth."[81] And so were Heller and Adler.

"Ghost"

Fact A3 of the 2005 evidences list says "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)."[82] This very thin (200-600 nanometers thick in image areas)[83],

colored, carbohydrate impurity layer on all superficial linen fibers on sticky tape samples from all sorts of Shroud areas, may have mainly consisted of the starch that had been applied as a thick paste on the threads during manufacture of the cloth, and largely had been washed off after the weaving, and that probably had completely turned into the image color substance in image areas – just like the image color substance on the fibers, also the Ghosts of image fibers only lost their image color by reduction in diimide[84]–, and that (partially) turned into pyrodextrins in light-scorch areas.[85]

In 1984, Jumper, Adler, Heller et al., reported on image fibrils: "these fibrils do not appear to have any coating", because no meniscus was seen in magnifications upto 1000 X in polarized light, not even on the joints of the linen fiber cells.[86] In phase-contrast, corroded surfaces were found, which they interpreted as corroboration for the seeming lack of a coating, probably thinking only of the lack of a coating of a paint/pigment binder. In fact they said the corroded surfaces were there "as would be expected for an oxidatively degraded cellulosic material".[87] But a starch coating might be regarded as a kind of cellulosic material, as starch consists of the same glucose units as cellulose does, but is more easily degraded. Note that Heller and Adler only called the body-image, non-image and scorch fibrils "the uncoated fibrils" to contrast them to "the red and golden yellow coated fibrils", i.e. blood- and serum-coated fibrils.[88] That no meniscus of a viscous fluid was found on the linen Shroud fibers, including the joint locations of fiber cells, might be explained by the warm-washing of the cloth, which largely would have removed a thick, completely covering, starch coating, leaving only a thin, completely covering, insoluble starch film. The original starch paste was used as a lubricant during weaving, so it would have been present at the intersections of warp and weft threads: especially between the threads, not only on the highest parts of the weave. Note that the Ghosts are also continuous over the joints of fiber cells – also called growth nodes – [89], which seems to suggest the Ghosts weren't (only) primary cell walls. The thickness of the Ghosts (200-600 nm) perhaps also precludes that they only consist of the primary cell wall of the linen. More recent experiments estimated the thickness of the colored layer to be 200 nm +- 200 nm; a primary cell wall would be only about 200 nm thick.[90]

Rogers wrote in an email to the Shroud Science Group: "It is still possible to see places on the sampling tapes from 1978 where image color was stripped off of image fibers. The thin, colored layer is still stuck to the adhesive of the tape. These colored "ghosts" still show all of the chemical properties of the complete image fibers. The image color is not a result of any changes in the cellulose of the linen fibers. The cellulose of the image fibers is still colorless"; in another e-mail he wrote "The layer of image color was often pulled off of the fibers by the adhesive of our sampling tapes in 1978. The layer is approximately one wavelength of visible light thick (200-600 nanometers), and it is amorphous. It can be specifically reduced with diimide, leaving a colorless flax fiber behind. Diimide reduction confirmed the presence of double bonds. The problem became, what could produce a color in a thin layer without affecting the structure of the cellulose? We had found starch fractions on the cloth during chemical testing. I had to hypothesize that image color had formed in a layer of impurities. I studied the chemical kinetics of the impurity materials and concluded that it was improbable that the impurities had been scorched by heat or any radiation source: the crystal structure of the flax image fibers was no more defective than non-image fibers."[91]

Here, Rogers doesn't mention the primary cell wall, and doesn't say that the fibers were intact or undamaged after the layer had been pulled off. He only says that in image fibers the crystal structure of the cellulose – i.e. the strong crystalline material within the cells – was no more defective than that of non-image fibers. Note that this does not preclude that the image was formed by UV-radiation or Corona Discharge, for the experiments of Di Lazzaro et al. (ENEA report 2010) showed that the cellulose of VUV-irradiated and image-colored linen fibers was no more defective than the cellulose of not irradiated fibers.[92] The same result was obtained by Fanti et al. (reported in 2005) in experiments coloring linen fibers by Corona Discharge.[93]

Also Rogers' following remark doesn't say the primary cell wall was not colored, or undamaged by pulling off the Ghost: "On 14 March 1981 ... most surprising results were reported by Professor Alan Adler of Western Connecticut University. He had found that the image color could be reduced with a diimide reagent, leaving colorless, undamaged linen fibers behind."[94] After this

chemical reaction with diimide, the fibers were "colorless, undamaged linen fibers", because the image color was not removed by stripping off the coating or removing the coating with a reactant, but was only chemically treated with the strong reductant diimide, donating electrons to the oxidized coating and thus rendering it colorless again.
In 2008, Svensson published a phase-contrast photomicrograph of a fiber, vacuumed from the buttocks area of the back of the Shroud in 1978, on which a rough surface layer is seen. It's described as "a snake/cobblestone-like layer"; "This layer is similar to the layers, which by some researchers have been interpreted as a "biocoating", i.e. a mix of fungi and bacteria called "Lichenotelia".(12) On hemp fibers - which can be compared to flax - LGT has sometimes seen approximately similar layers estimated to be pectin. But in this case it is impossible to rule out traces of biologic activity (fungi and/or bacteria)."[95] If it's not certain that this cobblestone-like layer is original pectin from the flax fiber's primary cell wall, it might very well be an applied amylopectin/amylose layer from starch.

2.2.2. Raes sample – 'red' starch: yes

Another quote from Rogers: "Some starch could be detected on HCl-cleaned Raes fibers with an aqueous iodine reagent. … I arranged two heavily-encrusted fibers from the outer surface of Raes #5 … The horizontal cotton fiber in figure 16 shows a deep-red coloration."[96]
In her report, published by the Holy Shroud Guild, Nitowski wrote: "Among other Shroud topics, Dr. Gonella and I spoke briefly about the Rogers Mylar tape samples on loan to Joseph Kohlbeck, my colleague, and currently in my possession. Included with those samples is a small glass vial labeled "Raes sample" containing a 12 mm long thread (see photo slides #40 & #41). I told Dr. Gonella that Kohlbeck had found it to be coated with starch by an iodine test (Photo slide #42)."[97] Photo slide 41, published by the Holy Shroud Guild, shows that the vial is numbered 5[98]; the Holy Shroud Guild also has published Kohlbeck's slide 42, which shows that all fibers visible on the slide, both thick and thin, have turned red with iodine.[99]
Note that the thread in the glass vial numbered 5, might have been the 12 mm long weft thread that was separately removed from the Shroud itself in 1973 before the Raes corner was cut.[100] It was removed from the Shroud near the corner that was cut off for Raes, but didn't belong to the cut off triangular piece of cloth. The thread was consigned to Raes.[101] But, because Nitowski wrote Kohlbeck received his sticky-tape samples from Rogers,[102] and Kohlbeck also explained to Bracaglia of the Holy Shroud Guild that he received his samples from Rogers,[103] it is more probable that Kohlbeck's 12 mm thread was the Raes thread that came from the triangular cloth sample itself, and that was sent to Rogers in a bag containing 14 Raes threads, and that Rogers photographed and numbered and put in vial numbered 5.[104]
Benford and Marino reported: "In 1982 an unauthorized Carbon-14 dating test was conducted on a single thread from the Raes sample. …. Adler informed Rossman that one end of the thread contained, what appeared to be, a "starch contaminate.""[105]

2.2.3. Comparison: both have 'red' starch

Raes thread #5 (a warp thread) and Kohlbeck's 12 mm thread (probably the same as Raes thread #5) apparently show the same kind of 'iodine-red' starch impurity as the starch impurity found on the main Shroud.

2.3. Madder dye

2.3.1. Raes threads – Madder: yes

Rogers detected a natural dye on fibers from the Raes threads. The color of the coating of the fibers changed with acidity (pH), in the way a natural dye, such as a Madder root extract containing the colorants alizarin and purpurin would, when it is dissolved in the coating of the fibers.[106] "Madder has been cultivated as a dyestuff since antiquity in central Asia and Egypt, where it was grown as early as 1500 BC. … It was included in the Talmud as well as mentioned in writings by Pliny the Elder, and other literary figures, as 'rubio'".[107] Purpurin is yellow in an

aqueous solution (pH 4 and lower)[108], but alizarin is slightly different: "It is yellow below pH 5.6, red above pH 7.2, and purple above pH 11.0."[109] Rogers also observed various amounts of bright red lakes and a few blue lakes of this dye, stuck to the coating of the fibers. A lake is a substance in which a dye is dissolved and takes a certain fixed color. The red and blue lakes, observed by Rogers, indicate the presence of hydrous-aluminum-oxide crystals (red lakes) and aragonite or calcite crystals (blue lakes) on the coating.[110]

Radiocarbon dating sample

Freer and Jull, who performed a merely photomicrographic study, reported to have found "no evidence for either coatings or dyes" in "a sample of the Shroud of Turin, split from one used in the radiocarbon dating study of 1988 at Arizona."[111] As the coating of the Raes samples "can be completely invisible on a normally prepared slide"[112] and also is much thinner on linen fibers than on cotton fibers,[113] it is perhaps no surprise that Freer and Jull saw no coating on their piece from the radiocarbon sample, especially as their piece did hardly contain cotton from the selvedge of the Raes sample.[114] As the Madder dye was in the coating, only the observation and identification of occasional red or blue Madder lakes would have hinted at the dye's presence.

2.3.2. Main Shroud – Madder: yes, probably, causing background fluorescence

McCrone claimed he saw Madder on some main Shroud sticky-tape samples, e.g. on a non-image sample, numbered 3AB, and a sample from a blood area, numbered 3CB.[115] Heller and Adler found no dyes in the tested particles from image areas,[116] but here must be noted that particles that they considered to be contaminants, such as "rose madder" particles, were not considered a particle type and had been excluded from chemical testing.[117] In fact, Heller and Adler did identify rose madder particles on the Shroud: "A somewhat more serious type of contaminant is the occasional appearance of materials that can be clearly identified as artistic pigments such as rose madder or cinnabar, etc."[118] So, as there were Madder lakes on the sticky-tapes, Madder dye may have been present dissolved in the colored coating ("Ghost") of all fibers as well.[119] In fact, Heller and Adler reported in 1981 that non-image fibers had a "pale yellow" color.[120]
They also reported in their official article: "There is no chemical evidence for the application of any pigments, stains, or dyes on the cloth to produce the image found thereon."[121] Here they noted that "positive tests in some cases would have been more meaningful than the negative tests", just as in the case of tests for starch.[122] As the official article only states that there is no evidence for dyes to produce the image, this does not preclude the presence of dye in the background. If non-image fibrils were tested – which is questionable –[123], the starch coating, with possibly traces of Madder dye dissolved in it, might have been left in the adhesive of the sticky-tape (as "Ghosts"[124]). On image fibrils, the starch with Madder dye probably was transformed into another substance in the image-formation process. This possible transformation of Madder dye is corroborated by the UV-fluorescence photographs of the Shroud.

UV-fluorescence

Natural Madder dye contains two colorants: the polynuclear aromatics alizarin and purpurin (purpurin as a minor component)[125]: "Purpurin fluoresces yellow to red under UV light."[126] Alizarin's fluorescense peaks at 485 nm, in the blue.[127] A violet wavelength ranges from about 380 to 450 nanometer,[128] and overlaps the blue range of approximately 440-490 nanometer.[129] Rogers wrote "The background of the Shroud is weakly fluorescent with a maximum intensity at about 435 nanometers wavelength, in the blue. The image did not fluoresce at all. The background fluorescence was in the correct range to be explained by polynuclear aromatic chemical compounds, which could help confirm the technology used to produce the cloth. Some materials with the correct properties are produced by *Saponaria officinalis*, the "soapweed" that probably was used to wash the cloth after it was woven."; he also showed the graph of the measured spectra of the background fluorescence.[130] However, chemical tests for certain components of Saponaria on the Shroud were negative.[131] Adler, when describing the fluorescence tests, wrote "The background cloth shows a light greenish yellow emission not typical of other known old linen cloths and perhaps suggesting the presence of some type of thin coating of a fluorophore on the

Verwijderd: 7 and higher

Verwijderd: , while synthetic alizarin slightly shows violet

Verwijderd: The UV absorption spectrum of alizarin peaks at 249 nm and 432 nm

Verwijderd: UV-vis

original linen."[132] He also showed a photograph of this blue-green and yellow fluorescence in the background of an image area.[133]

Now, the 435 nanometer of the maximum Shroud-UV-fluorescence might be called violet or blue, and is in the correct range to be explained by alizarin of Madder dye and/or by lignin of the linen fibers, which fluoresces light blue.[134] The yellow, also present in the Shroud's fluorescence, then might be explained by the presence of yellow-fluoresceing purpurin of Madder.

Verwijderd: UV-Vis

Weave striations and mottled look

The Shroud's background fluorescence is not uniformly yellow-green. When describing the Shroud's fluorescence, Miller and Pellicori said "Weave striations are obvious in fluorescence" and "The cloth weave striation is an apparent nonuniformity."[135] The dyeing with Madder initially would have covered a visible lignin banding of unevenly bleached linen, but probably added a second fluorescence banding to the fluorescence banding of the lignin, because starch, wiped on the cloth in thicker or thinner bands during weaving (with washing not completely undoing this nonuniformity), would hold more or less fluorescent Madder within, also after the Madder largely evaporated. Also, in many places all over the Shroud, the fluorescence shows "blue flecks, thought to be modern lint contamination".[136] Gilbert and Gilbert said the Shroud has a "mottled look throughout", in the visible reflectance.[137]

Verwijderd: UV-vis

Verwijderd: UV-vis

Blue fluorescence = no print

Verwijderd: UV-vis

Moreover, the Shroud's image shows weave-dependent segments which fluoresce blue and don't show the image that should have been there: "Ventral feet, knees and thighs – 19 through 22 (Figure 10) .... The leg outline and scourge markings are limited by a weave line appearing blue in fluorescent emission where the weave direction changes. This is an area of "no-print".[138] Weave areas at the sides of the face show the same lack of image density, which is attributed to a property of the linen thread.[139] "An abrupt change in the image density can be seen in Fig. 4 at a single warp thread at the side of the face. ... In this particular region, the radiographs show no discontinuity in the cloth areal density; it can, therefore, be concluded that adjacent warp-thread-lots differed either in their surface or chemical characteristics."[140]

This supports Adler's idea, published in 2000,[141] that there is a yellow-green fluoresceing coating on the blue fluorescent linen, for at some places the coating may not have been applied well, and have left the bare linen less sensitive to image formation than the coated fibers. Where a starch paste had not been applied to the warp threads, the subsequently applied Madder dye would have found no binder, either. Perhaps, also, at some blue flecks, the coating fell off by abrasion (as a "Ghost"-coating was removed by sticky tape sampling).

Not caused by aging or scorching

Pellicori reported, in 1980, that "basic linen blue-white fluorescence changed to faint yellow-green with baking"; this air baking in an oven (at 125 to 150 degrees Celsius) was a way to simulate aging and give a cloth a visible color and fluorescent emission that approach those of the Shroud.[142] Miller and Pellicori reported in 1981 that in "linen lightly scorched by a soldering iron in air shows the green-yellow emission, often distributed in plumes of deposited pyrolysis products. .... the material of the plumes could be transported by water, but the underlying scorched cellulose retained a bright yellow-green fluorescence."[143] This demonstrates that the blue fluorescent areas of the Shroud can not be the result of loss of a green-yellow fluorescent linen pyrolysis/degradation layer, but rather are the result of the absence of a fluorescent coating (never applied or lost).

Verwijderd: green-yellow

"The faint water stain between the head images has light blue boundaries in fluorescence."[144] Here, it seems the madder somehow dissolved in the water and evaporated with the water. This is more probable than that the water would have undone the aging process of the linen, or would have prevented it. Other water marks have "light border areas" in fluorescence[145], while a water mark above the ventral knees is brown-fluorescing,[146] perhaps from scorched material that got washed to the water stain border. Blood stains, scorches and the body image all quenched the background fluorescence.[147] "Pellicori reported that ... the margins of the scorches fluoresced in the green, entirely different than the background of the Shroud."[148]

Present before bloodstaining

Another indication for a yellow-green fluorescing coating might be the fluorescence of serum

coated fibers around the wounds: "Circles of yellow-green fluorescence are associated with these wounds".[149] Adler said "Also the border of every blood mark shows the typical yellowish fluorescence of the serum exudate ring around scabs as expected for clot retraction transfer marks"[150]. As serum coated fibers in image areas have no image underneath,[151] their yellow-green fluorescence might be the result of the underlying starch/madder coating, which fluorescence wasn't quenched by image formation because the serum protected the coating. The fluorescence wouldn't be from yellow-green fluorescing aged linen, for the serum coating would have retarded the aging, just as it retarded/prevented the image formation and its quenching of the fluorescence. Of course the yellowish fluorescence may also result from the serum itself.

Present before scorching and image formation

The fluorescence data for scorches and image areas, when compared to clear areas, show a reduction of fluorescence and a shift of the maximum fluorescence to longer wavelenghts. The explanation of the peak shift used to be not definitive. An attenuation of the excitation and background fluorescence through the scorches and image was suggested by Schwalbe and Rogers; the Gilberts suggested the addition of a low-level 600-700 nm fluorescence of the scorches and image themselves.[152] If the reduction of fluorescence is the result of attenuation of the incident and emitted radiation through the scorches and image, this would mean that the background fluorophor was present under ánd before the scorches ánd the image were.

"At the center of the dorsal head, a blue fluorescence is noted. This has a different color than the body image."[153] Here, perhaps some heavy liquid contamination on the cloth – aromatic and possibly fluorescent spikenard oil from an anointed head (Mr 14,3)? – withheld proper image formation. Or else perhaps the starch-madder coating was abraded here before image formation.

Not from pectins or Saponaria

In 1997, "At the Nice conference, Mottin suggested, that the background fluorescence of the Shroud might be due to the presence of pectic substances not removed by primitive retting methods."[154] Adler and Heller indeed found pectins chemically,[155] but pure pectins are not auto-fluorescent: of the components of the cell walls of a linen fiber only lignin is fluorescent (light blue).[156] A "linen treated with saponaria glucoside" "shows a fluorescent contribution <450 nm."[157] If Saponaria soap was responsible for the Shroud's background-fluorescence, it was used to wash out the starch from the cloth, and the soapy washing solution probably would have been a base, i.e. having a pH well above 7.2.[158] Then any Madder in the last wash would have turned red or purple, which was unwanted for a white/pale yellow bleached linen cloth. So, either Saponaria or Madder would have caused the background fluorescence: they can't have been used together. A search for chemical and physical evidence of Saponaria on the Shroud did not yield any positive results,[159] but Madder has been reported. Note that Villarreal presented photomicrographs of a flat, yellow, twisted fiber from a tape sample of the main Shroud, that fluoresced yellow in UV-illumination, perhaps indicating Madder on cotton.[160]

Intensity reduction by transformed Madder

If the carbohydrates alizarin and purpurin[161] were dissolved in the starch coating and this starch coating was completely transformed into the image color coating of conjugated carbonyl (which is probable, see 4.2.4.), then also the alizarin and purpurin probably were transformed, and this would explain why the background fluorescence was quenched by the image formation process.[162] The peak shift in scorch areas may be the result of the addition of a low-level 600-700 nm (= reddish) fluorescence from a furfural-type that was formed during oxygen-poor scorching[163]: furfural was detected in scorch areas (see 2.6.). But in image areas, there was no oxygen-poor scorching, for the fibers' medullas look clear, not charred as in scorched fibers, and the visible color in fluorescence photographs is obviously different, and the fluorescence spectrum of scorched fibers show "a subtle weighting toward the orange region relative to the curves for body image".[164] So, in image areas the very subtle peak red shift may be explained as the sum of a blue shift caused by loss of madder dye fluorescence, on the one hand, and a red shift caused by quenching of the blue lignin fluorescence by the visibly straw yellow and thus blue absorbing image layer, on the other. A similar fluorescence reduction and peak shift that was produced "to some extent by the mottling in the background areas" of the Shroud[165]: in mottled looking areas there may be very light scorching or uneven surface oxidation through ageing.

Verwijderd: Peak shift

Verwijderd: the peak shift is best explained as the result of the subtraction of a low-level violet fluorescence from Madder alizarin that was transformed in the image formation process, leaving relatively more lignin (= blue) fluorescence behind in the 'half-tone' image. This explanation is corroborated by the

Verwijderd: the Madder coating probably had been abraded or never applied well, resulting in relatively less alizarin in these areas

Permanent Madder fluorescence

A coating of retrograded starch including a dilute acidic Madder dye (as batch-uniforming color and optical brightner) might keep most of its fugitive fluorophores alizarin and purpurin, if it was glazed by firmly rubbing it with a glass ball or slickstone,[166] such as the Viking-type linen smoother[167] or the Dutch smoothing balls from the 8th and 9th centuries[168], to render it more dense and sealing, and thus dirt repellant and lustrous. Number B14 of the Shroud evidence list says "The TS linen has a lustrous finish (Rogers, 1978-1981)."[169] This is another corroboration for the Shroud being a robe as Herod's 'estheta lampran' (Luke 23,11 WH), literaly "shining robe" (Bible in Basic English), "brilliant robe" (HCSB), "glistening clothing" (LEB), also translated as "white cloak" (WYC) and "kingly robe" (NCV).[170] The sealing starch finish would also have retarded the aging of the very tightly woven linen Shroud (evidence B5). Saponaria Officinalis, also called struthium, was not detected on the Shroud: Rogers said "I could not prove that the cloth had been washed in S. Officinalis. Only the fluorescence evidence remains to suggest the use of struthium".[171]

Raes area

Adler, Selzer and DeBlase reported that fibers from three threads from the radiocarbon sample, under microscopic investigation, "resembled exaggerated versions of waterstained specimens. They were non-fluorescent, unevenly colored from dark yellow to splotchy brown, roughly surfaced (even showing patchy encrustations in spots) and showed a very strong and variably multicolored birefringence pattern. Considerable microdebris was also evident."[172] As the radiocarbon area is a light-scorch area, the "extremely fugitive" fluorescent colorants of ancient madder, alizarin and purpurin,[173] may have evaporated from the roasting starch (gum), leaving the starch non-fluorescent (and roasting to yellow-brown starch gum), more or less like the yellow iodine solution that had been dissolved in the gum by Rogers, evaporated from the gum overnight, leaving it colorless.[174] "After studying ultraviolet fluorescent photographs taken of the Shroud, STURP's chief photographer Vernon Miller and Alan Adler confirmed over 15 years ago that the radiocarbon site was in the midst of a scorch mark and at the edge of a water stain.(14)"[175] The roasting of the thickly coated threads in this area apparently was not hot enough to scorch all fibers of the threads and render all of them red fluorescent[176]; the fiber samples, taken by Adler, Selzer and DeBlase from the radiocarbon threads, may incidentally have been not from the top of the weave and therefore may have been not hot enough to scorch hemicellulose to its fluorescent scorch products.[177]

Pectins

Structural pectin, a "structural heteropolysaccharide contained in the primary cell walls of terrestrial plants"[178], was expected to be present on the primitively retted linen, for it is the plant cement between cells of linen fibers.[179] McCrone had seen a thin film on fibers, and tested it for proteins with the reagent Amido black: the test was positive, but Heller and Adler showed this test is also positive for pectins.[180] They tested fibers with the more pectin-specific reagent Ruthenium red and with the enzyme pectinase: thus pectins were detected on non-image fibers from the sticky-tapes and on fibers from threads from the radiocarbon area, but they weren't detected on image fibers.[181] In image areas any structural pectin from the flaxplant, or any structural pectin from a primitive madder root extract (madder dye)[182] (and also storage amylopectin from starch), would have been degraded by the image formation process.

2.3.3. Comparison: both have Madder

So, it seems plausible that the whole cloth had been dyed with Madder. This dye is very fugitive and that may be the reason why it doesn't hide the slightly differently bleached batches of the cloth's weave anymore, as it may have done when the cloth was brand new. In 769 AD Pope Stephen III reported to have seen Jesus' whole body on a cloth white as snow.[183] If only a medieval patch in the Raes corner had been dyed to match the sepia color of the aged cloth, then the differences in discoloring would have revealed the patch later: the 'new' patch would have lost its fugitive Madder color and have become lighter, but the surrounding cloth would have darkened through further aging.

As the X-ray fluorescence didn't detect paints and dyes on the cloth, it apparently missed the Madder in the Raes area, seen by Rogers. So, it would have missed the Madder on the rest of the cloth as well. Madder dye is an organic carbohydrate without inorganic elements having an atomic number above 16, and it indeed would not have been detected: "X-Ray fluorescence is a very powerful method to determine the concentration of inorganic elements having an atomic number above 16 with accuracy depending on the element."[184] "The technique cannot be applied directly to detect low-atomic-number organic dyes or tempera vehicles."[185]

2.4. Madder lakes (aluminum and calcite particles)

2.4.1. Raes and radiocarbon samples – Madder lakes: yes

Besides the Madder root dye or a similar dye, found by Rogers when yellow-brown surface fibers from Raes thread #14 reddened in NaHCO3 at pH 8.0, and turned purple in 2N NaOH at a high pH,[186] Rogers also found red colored lakes (a dye dissolved in mordant[187] crystals) in Raes and radiocarbon sample threads: "HCl (6N) brings the lakes into solution and turns bright yellow. ... The red lakes are diagnostic for Madder root dyes and alum. The solubility characteristics of the red lakes indicate AlO(OH). ... The red dye/mordant lakes dissolved in 2N NaOH to give a purple solution. The presence of aluminum in the coating material is consistent with the results of Adler, Selzer, and DeBlase [7], who performed X-ray elemental analyses on different shroud materials, including fibers from radiocarbon-sample warp threads. They reported concentrations of aluminum on the radiocarbon sample 20-times those on shroud fibers. Mordants other than AlO(OH) produce different colors with Madder root dye. Calcium compounds produce blue colors, and a few blue lakes can be seen on some gum-coated fibers. They are removed with 6N HCl. The color suggests alizarin on crystals of calcite or aragonite in the threads."[188]
In 2005, aluminum had not been found, when Brown wrote about the coating of the Raes threads: "Chemical elements such as C, O, Cl, K and Ca have been detected in the coating, but complete analysis is still an ongoing project."[189] In 2008, Villarreal reported that the spectra obtained by X-ray Photoelectron Spectroscopy from Raes thread #1, showed the expected carbon, oxigen, and nitrogen from organic fibers, and the unexpected calcium and silicium, but no aluminum; also in the thread's Rhodium X-ray Excitation Spectra, Villarreal "did not see any aluminum".[190]

2.4.2. Main Shroud – Madder lakes: yes, identified but excluded from chemical tests

Heller and Adler found no dyes in the chemically tested particles from image areas,[191] but here it must be noted that particles that were considered contaminants, such as Madder lakes, had been visually identified and excluded from chemical testing. "A somewhat more serious type of contaminant is the occasional appearance of materials that can be clearly identified as artistic pigments such as rose madder or cinnabar, etc. … For a given tape, an arbitrary minimum threshold of 15 specimens of a particular type of visually identifiable characteristics (mainly color and surface appearance under phase contrast microscopy) was set to constitute a class of fibers of particles assignable to a specific location on the cloth to be subjected to chemical testing. … Carrying out this prescription excluded all the various types of contaminants discussed above and yielded 11 classes of sample objects or testing."[192] Ford wrote, referring to what McCrone saw on the sticky-tape samples from the main Shroud: "McCrone believes he saw merely "a few particles" of rose madder pigment".[193]

2.4.3. Comparison: both have occasional mordant particles

If the red lakes, detected by Rogers, and possibly seen by McCrone and Adler, were alizarin on crystals of AlO(OH) (hydrous aluminum oxide), the aluminum needn't have been a deliberately added mordant. Adler, Whanger, and Whanger, had suggested in 1997 that the aluminum present in the waterstain margin of the radiocarbon area in relatively high concentrations, may have been aluminum of the salts of the water that had diffused to, and stopped at, the apparently already cut off missing corner: the cutting edge of the cloth had created a boundary for the water diffusing through the cloth.[194] If the blue lakes were alizarin on calcite or aragonite crystals, also these

crystals needn't have been added deliberately. Jeruzalem limestone, found on the image of the sole of the crucified man on the Shroud and in the rock of Jerusalem burial tombs and near the Damascus Gate of Jerusalem, contains travertine aragonite.[195] Some Jerusalem dust may thus have simply settled on the cloth, when it was drying there after it had been dyed. Anyway, a uniform and deliberate aluminum or calcite/aragonite mordant for Madder would have colored the cloth red or blue, not pale yellow. Starch doesn't change the pH of a solution,[196] so a solution of Madder extract, made by boiling crushed madder root in acidified water,[197] would remain acidic in starch and keep its acidic yellow color (below pH 5.6).
It is possible that the Madder root extract was simply applied to the starched and washed cloth, without any mordant, knowing that the starch coating would act as a better binder for the dye[198] than the linen itself. On any other garment, the first hot wash would remove the starch-and-dye film immediately. But as the cloth of the Shroud was meant to be a temple garment, it would never get washed, and its dye could safely be applied on the removable starch film, that strengthened the cloth. And because a temple garment, when it got dirty or torn, would simply be replaced, its dye wouldn't need fastness against light either, for any discoloring by light would appear more slowly than discoloring by blood and dirt from the many sacrificial animals that were slaughtered by the priests in the temple every day.

2.5. Gum crust

2.5.1. Raes and radiocarbon threads – flaked starch gum coating

Rogers wrote in 2005: "Raes threads show a yellow-brown coating. All Raes threads show colored encrustations on their surfaces. Some sections of medulla contain some of the material, showing that it had been able to flow by capillary attraction as a liquid. The encrustation is not removed by nonpolar solvents, but it swells and dissolves in water. … The encrustation is heaviest on cotton fibers, it is the vehicle for the yellow-brown color, …. When I teased threads open at both ends with a dissecting needle, the cores appeared to be nearly colorless. This observation suggests that the color and its vehicle were added by wiping a viscous liquid on the outside of the yarn".[199] He showed micrographs of Raes threads R5 (warp) and R14.[200] "The coating was insoluble at pH 8.0 but dissolves at both lower and higher pH."[201] "The gummy coating was totally hydrolyzed by concentrated HCl and 2N NaOH. That fact and its solubility in water suggest that it is probably a polysaccharide and not a denatured protein. The fact that some hydrolyzed in 6N HCl suggests that it is probably a polypentose, composed of five-carbon sugar units. However, not all of the polysaccharides on the fibers were removed by concentrated HCl. Higher-molecular-weight starch fractions are much more difficult to hydrolyze than are polypentose-containing plant gums. Some starch could be detected on HCl-cleaned Raes fibers with an aqueous iodine reagent."[202] This starch colored red with iodine,[203] so, the gummy crust was on top of coating of amylopectin, retrograded starch, or not totally pyrolyzed starch gum. Rogers assumed that the crust was a plant gum, and suggested gum Arabic: "The relatively easy water solubility and hydrolysis of the encrustation suggests gum Arabic. It is obtained from *Acacia senegal*, and it is mostly composed of pentose-sugar units. It turns bright yellow in aqueous iodine, as observed on the Raes threads."[204] Note that "The iodine was in simple solution in the gum."[205] "I let the water and iodine evaporate overnight. The redeposited, colorless, gelatinous material is clearly visible along the fibers in figure 16."[206] "Both Raes and radiocarbon samples give this reaction."[207]
A concentrated aqueous iodine solution that is brown colored[208] will look bright yellow when it is diluted.[209] So, any gum that doesn't contain long starch chains simply absorbs the brown iodine solution and dilutes it to a bright yellow color and doesn't color red (indicating e.g. amylopectin) or blue (indicating amylose).[210] The fact that some of the polysaccharide crust hydrolyzed in 6N HCl may suggest a polypentose-containing plant gum, but it might as well suggest other low-molecular-weight polysaccharides, such as small achrodextrins of starch gum.[211]
The abstract of the research results of Villarreal, Schwortz, and Benford says about the Raes crust, based on FTIR data: "The crust appeared to be an organic-based resin, perhaps a terpene species, with cotton as a main sub-component."[212] Starch and Madder are both organic, and the observed

deposit of dirt from the excessive handling of the Raes corner, would contain human squalene, which is a triterpene.[213] Villarreal said the crust was possibly a terpene based resin "because of the hydroxyl groups: there's only a limited number in terpene, while there are many in cellulose."[214] Also alizarin and purpurin of Madder have a limited number of hydroxyl groups (-OH groups) in comparion with cellulose.[215]

Starch gum = scorched starch

Crude starch is a plant product, and when it is cooked in water, it forms a viscous solution (a paste) that can be wiped on the outside of linen yarns. When it cools down, dries and thickens, it will partly retrograde to a semi-crystalline structure.[216] "If starch is subjected to dry heat, it breaks down to form dextrins, also called "pyrodextrins" in this context. This break down process is known as dextrinization. (Pyro)dextrins are mainly yellow to brown in color and dextrinization is partially responsible for the browning of toasted bread."[217] "Dextrins are a group of low-molecular-weight carbohydrates … Dextrins are mixtures of polymers of D-glucose units by α-(1→4) or α-(1→6) glycosidic bonds. Dextrins are white, yellow, or brown powders that are partially or fully water-soluble, yielding optically active solutions of low viscosity. Most can be detected with iodine solution, giving a red coloration; one distinguishes erythrodextrin (dextrin that colours red) and achrodextrin (giving no colour)." [218] Dry heating starch with little or no acid produces a yellow-brown dextrin, called British gum, [219] which gives no (red of blue) colour with iodine[220]. British gum has "significant properties of great water-holding capacity, high viscosity, and also improve stability and solubility."[221] Another name for British gum is starch gum; because it much resembles gum Arabic, it is generally substituted for gum Arabic.[222]

Radiocarbon area is a scorch and waterstain area

In 1996, Adler reported, when commenting on FTIR data from the Shroud: "In fact, the radiocarbon fibers appear to be an exaggerated composite of the water stain and scorch fibers."[223] He confirmed this observation in 2000: "In fact, the FTIR data for the radiocarbon sample, in a sense confirming its inappropriate physical location, shows physical characteristics of both the waterstain and scorch regions of the cloth."[224] On the radiocarbon sample he said: "Only a single sample was taken ... from the edge of a bounded waterstained scorch area ..."[225] Antonacci recapitulated in 2005: "Adler clearly demonstrated that the radiocarbon samples have a different chemical composition than most of the fibers from the rest of the Shroud; however, he understood they're merely "an exaggerated composite of the water stain and scorch fibers."(13) After studying ultraviolet fluorescent photographs taken of the Shroud, STURP's chief photographer Vernon Miller and Alan Adler confirmed over 15 years ago that the radiocarbon site was in the midst of a scorch mark and at the edge of a water stain.(14)"[226] "Adler's studies, Miller's photographs, and the photographic positive in Sindone 2002 show the radiocarbon site was part of the Shroud when the water stains were put on the cloth. Moreover, Miller's observations on the UV fluorescent photographs and reflected light imagery from 1978, along with Adler's above studies, strongly indicate the radiocarbon site chosen in 1988 was present when the scorch marks of 1532 were incurred."[227]

The corners of the Shroud were excessively handled through the ages, at least since 1357, so the dirt on the corners probably contain fatty-acids and squalene from human hands.[228] Therefore, the top of the starch coating of the radiocarbon area may have roasted in an environment with little or no acid, and have become yellow-brown British gum (giving no red colour with iodine, because no long starch chains are present anymore). Underneath the top layer the starch coating would have had no contact with acid and was perhaps roasted at a lower temperature to erythrodextrin (giving a red colour with iodine, because some long starch chains are still present). Any unroasted amylopectin left in the bottom layer would also colour red with an iodine solution.

Adler reported in 1998 about threads from the radiocarbon sample: "Two were warp threads from the outer and inner edges of the trimmed sample and the third was a weft thread from the middle of this sample. Five fibers were taken from each of these samples for comparison with those collected from the sticky tapes. Interestingly, under microscopic investigation, these samples resembled exaggerate versions of the waterstained specimens. They were non-fluorescent, unevenly colored

from dark yellow to splotchy brown, roughly surfaced (even showing patchy encrustations in spots) and showed a very strong and variably multicolored birefringence pattern. Considerable microdebris was also evident."[229] A roasted crust of a thick uneven starch coating, matches the observed uneven color and rough surface with patchy encrustations, more than an (unroasted) coating of a whiped fluid of gum Arabic would. The very strong and variably multicolored birefringence pattern perhaps results from the excessive handling of the corners of the Shroud, causing many dislocations (defects) and microcrystalline zones in the cellulose of the fibers.[230] It could also be explained by the samples' resemblance to waterstain specimens, whose particulates, stuck to the fibers, were reported to be "birefringent, pleochroic"[231] – pleochroic meaning 'variably multicolored birefringent'.

Pentoses

As will be explained below (paragraph 2.6.), the weak positive tests for pentoses or furfural from Raes threads (with Bial's reagent),[232] can be explained by the presence of furfural, which is a scorch product of the hemicellulose of the linen cell walls in light-scorch areas such as the Raes corner. Hemicellulose is a polysaccharide of many different sugar units, including pentose units, such as xylose, which is present in the sugar chains in largest amount.[233] So, the positive test needn't have been the result of polypentoses of gum Arabic.

Proteins

Gum arabic is "a complex mixture of polysaccharides and glycoproteins".[234] A difference between gum Arabic and starch gum (British gum) is that gum Arabic contains proteins.[235] Except fibers from the blood areas, no fibers from main Shroud samples had tested positive for proteins.[236] Adler also tested fibers from the radiocarbon threads for proteins (protease test and FTIR spectroscopy): they gave a negative result.[237]

Not gum Arabic

- the gelatinous gum was seen on both Raes and radiocarbon fibers (yellow iodine solution dissolved in both places)
- gum Arabic contains (glyco-)proteins
- the gum crust is not a denatured protein (it quickly hydrolyzed in conc. HCl and 2N NaOH)
- no proteins were found on radiocarbon fibers

The combination of these observations indicates that the gum on Raes and radiocarbon threads is not gum Arabic.

2.5.2. Main Shroud – flaked carbohydrate coating (Ghost)

"Some of the tapes, are samples taken in the pre-dating 1192 area. Paul Maloney photo macro- and -micrographed this burn area sample. These photographs do show clearly the presence of straw-yellow fibers in the scorched areas."[238] These straw yellow fibers near the pre-1192 so-called 'poker holes' – possibly caused by burning pitch[239] –, may have had the same (but thinner) yellow roasted starch coating, as found on fibers in the light scorch area of the Raes corner.

If tested side by side the fibers from non-image, body image, and scorch areas, appeared to have "a progressively corroded appearance of their surfaces under observation by phase contrast microscopy"; the dark fibrils in scorch areas had "very corroded surfaces".[240] This is also consistent with an (unstable) starch coating that is progressively degraded by aging, image formation, and scorching, respectively.

"If preexisting impurities enabled image formation, some should have still been on the Shroud at the time of the 1532 fire. A search of tape samples from lightly-scorched areas revealed ghosts that appeared to be identical to those from image areas. Thin layers of colored impurities had stripped off from scorched fibers that were completely isolated from image areas (figure VII-3). Scorched fibers from the sample shown in the figure (STURP sample 1IB) were very slightly colored; however, scorches on the Shroud ranged from almost invisible to black. Figure VII-3: A line of yellow flakes stripped off of one side of a lightly-scorched fiber (800X). The outline of the other side of the fiber and some dispersed flakes are visible."[241]

The flakes that were stripped off of this lightly-scorched fiber, may very well have been identical to the encrustations of roasted starch of the Raes coating. STURP sample 1IB (also called 1CB) was taken from a scorch mark at the dorsal side, next to the feet.[242]

2.5.3. Comparison: both have a flaked coating in light-scorch areas

Rogers wrote about the Raes crust: "The encrustation is heaviest on cotton fibers, it is the vehicle for the yellow-brown color".[243] "The thickness of the coating on the Raes yarn varies greatly. Cotton fibers tend to have much thicker coatings than linen fibers; however, I would guess that the coating does not average more than about 2 µm thick."[244]
On the 'Ghosts' of image fibers: "The coating is too thin to measure accurately with a standard microscope; however, it appears to be 200-600 nanometers thick (in the range of a wavelength of visible light)."[245] "The color of the image is indeed a result of a thin coating. "Thin" is the important word. Surface cracking ("corrosion" as Adler called it) of the color can be seen, and flakes can be seen in the "ghosts" on the sampling tapes (figure VII-2). It takes a thickness on the order of a wavelength of light to get an observable change in index of refraction, and observed indexes of an image fiber are identical to those of a fiber from the Holland cloth or modern linen. The image-color coating seems to be amorphous, but I have been unable to measure its index. I have been able to measure the index of the gum coating on the Raes sample. The thickness of the image color must be less than a sodium-D wavelength (589 nanometers)."[246]
"Figure IX-3 shows fibers from the radiocarbon sample. The flat ones with a twist in them are cotton. Notice that both cotton fibers are completely covered by a colored layer. Some of the linen fibers are nearly clean."[247]
So, it is not just that 1) there is no, or hardly any, old cotton in the main Shroud, and, moreover, the 2% old cotton found in a thread from the edge of the radiocarbon sample at the main Shroud was 2) not on its surface but a spun-in contaminant, and 3) is much thinner than the surface cotton in the Raes threads. Also 4) the coating found on linen fibers of the main Shroud would have been much thinner and 5) thus with much less yellow-brown color than on an eventual thin old cotton surface fiber. 6) The sticky-tape samples broke fibers from the top of the weave of the main Shroud, which may have a thinner coating than fibers from the down-parts of the weave, between the intersection of warp and weft threads (originally or by later abrasion); only a (Raes) thread contained and showed all parts of its weave. So, for six accumulative reasons, the chance to find the Raes coating on the top of the weave of the main Shroud is much smaller than in a Raes thraed. Indeed, only the "Ghosts" on sticky-tapes made some researchers wonder if there is or isn't a coating on the Shroud fibers, because the Ghost is thinner than the wavelenght of the light used in microscopy, and thus invisible when still on the fiber. Moreover, 7) the indexes of refraction of the Raes coating, on one hand, and of the sticky-tape adhesive, of linen lengthwise, of cotton, and of 1.515-index microscopy immersion oil, on the other, are all approximately the same (very close to 1.515)[248], so also this contributes to the invisibility of a Raes coating when on the fiber, also on samples of the main Shroud. According to Rogers, even a thick Raes coating could be completely invisible: "The index of the coating on the Raes samples varies a little, but it is very close to 1.515: It can be completely invisible on a normally prepared slide."[249] Only the Ghosts were discernable as coatings, because they were empty.[250] Also 8) the color of the coating would only be yellow-brown in scorch areas of the Shroud. In light scorch areas a scorched starch coating is hard to discern by sight from scorched linen, as both are scorched carbohydrates. 9) Only in non-image light scorch areas the coating's water solubility and gelatinous property could perhaps betray its presence, but 10) a very thin scorched flaking coating may have been loosened from the fiber when the sticky-tapes were pressed unto microscope slides, then removed, and pressed unto microscope cover slips with hard compressinon, and/or washed away along with the sticky-tape adhesive when the scorched fiber was washed with toluene[251] in preparation for further microchemical testing, and 11) Ghosts of light scorch fibers apparently weren't tested with water: they were immersed in the sticky-tape adhesive or immersion oil when under the microscope. Only the Ghosts of image fibers were explicitly chemically tested, and appeared to have the same insolubility as the image color on fibers. But the process of image formation was not the same as the oxygen-poor scorching of the Raes corner and other light-scorch areas (their effect on fluorescence is different[252]). So, nothing

Verwijderd: these fibers or

Verwijderd: UV-vis

precludes that the gelatinous Raes coating is present as a very thin coating on the linen of light scorch areas of the main Shroud as well.
The big waterstains, also the one to which the Raes corner belongs, appear to have gotten onto the cloth before the fire of 1532: [253] before the insoluble starch coating roasted to a soluble starch gum coating that can be washed away. Most of the small waterstains from the water that quenched the 1532 fire reached the light-scorch areas,[254] so here a soluble coating of roasted starch may have moved and resettled elsewhere in the waterstain or at its margin or outside the cloth. Only never-wetted light scorches should have an unmoved, very thin, roasted starch coating; this condition is met on sticky-tape samples 3C-F, 4C-B and 1I-B – labelled Light Scorch –,[255] and perhaps in the straw-yellow fibers near the so-called 'poker-holes', photo-macro- and -micrographed by Malloney. And indeed, sample 1I-B showed "a line of yellow flakes" from a light-scorch fiber (Rogers, A Chemist's Perspective, p. 45-46, Fig. VII-3), confirming the presence of a scorched coating on the main Shroud, similar to that on the Raes corner.

Verwijderd: only

2.6. Pentoses or furfural

2.6.1. Main Shroud – pentoses: no evidence – furfural: yes, in scorch areas

It has been suggested that the Shroud was washed with Saponaria officinalis, a herb used in antiquity, and called soapwort. "In addition to starch fractions, we might expect traces of the glycoside sugars from *Saponaria officinalis* (e.g., galactose, glucose, arabinose, xylose, fucose, rhamnose, and glucuronic acid)."[256] Fact B58 says "It is unknown whether Saponaria officinalis can be detected on the Shroud (Rogers 2003; Jumper 1984 ; Gilbert 1980)."[257] Rogers wrote: "There was no evidence for any chemical products from *Saponaria officinalis* or any other coating on image fibers."[258] "In order to make a more detailed analysis for possible flax impurities and/or sugars from *Saponaria officinalis* (the "struthium" mentioned by Pliny the Elder), I made some Bial's reagent (orcinol, con. HCl and FeCl3). It gives a bright Kelly green color with pentose sugars or furfural. I could not get a clear positive test for pentoses from Shroud samples; however, I got some fairly weak tests for pentoses from Raes threads."[259]
A positive Seliwanoff's test for pentoses or furfural was obtained from scorched fibers of the main Shroud, while non-scorched non-image fibers gave a negative Seliwanoff's test. [260]

2.6.2. Raes sample – pentoses or furfural: yes

A fairly weak positive Bial's test for pentoses or furfural was obtained from Raes threads. [261] "A few spot tests for pentoses on Raes threads from the Shroud were just above the detection limit for the test, but they did not prove anything conclusive. We could easily detect the pentoses on modern linen that had been made by the ancient process."[262]

2.6.3. Comparison: both have furfural in scorch areas

The fairly weak positive Bial's tests for pentoses or furfural from Raes threads (providing much larger samples, with also non-surface fibers, than a sticky-tape main Shroud sample with only surface fibers) can be explained by the presence of furfural, which is a scorch product of the hemicellulose of the linen cell walls in scorch areas such as the radiocarbon corner/Raes corner. Hemicellulose is a polysaccharide of many different sugar units, including pentose units, such as xylose, which is present in the hemicellulosic sugar chains in largest amount.[263] Rogers said "Furfural inhibits the growth of molds and yeasts. Scorched areas are less likely to show microbiological attack."[264] So, Rogers expected furfural to be present in scorched areas. Perhaps that is why he wrote about the Raes threads' weak positive Bial's test: "I ignored the fact until much later." [265] He even tried to detect furfural in "a light Shroud scorch" with Seliwanoff's test on surface fiber(s) from a sticky-tape, but failed, and offered polymerization of the furfural by aging as a possible explanation for this negative Seliwanoff's test.[266] Nevertheless, in 2008, Rogers' book reported: "The Seliwanoff's reagent also gives a red color with levulose (fruit sugar), but it does not react with levulinic acid (a cellulose pyrolysis product). I got a red test with scorched Shroud fibers, but background fibers gave no color."[267] This shows that it is most probable that the

positive Bial's and Seliwanoff's tests were not the result of pentoses, but of furfural in the scorch areas, both in the Raes corner and on the main Shroud.
Antonacci commented on the detection of furfural release in pyrolysis mass spectrometry (PMS) of a Raes thread, at lower temperatures than its release from microscopic main Shroud samples in STURP's pyrolysis (oxigen-free heating) tests[268]: "It should also be mentioned that if the Raes samples (the only non-image area from which he used a sample) were in a lightly scorched area, as the radiocarbon samples were, bonds broken during the scorching of the cellulose may have allowed furfural to be released at lower temperatures."[269]
In a non-scorch sample there would be no (free or age-polymerized) furfural, because it still had to be pyrolyzed from the xylose in the hemicellulose (or Saponaria) while being heated in the pyrolysis mass spectometer, in order to become present and detectable; in the scorch areas, on the other hand, free or polymerized furfural would have already been present before the sample would get analyzed by pyrolysis mass spectometry, because of the oxigen-poor heating and pyrolysis of the cloth's hemicellulose in its closed box in the historical church fire of 1532 AD.[270]
Now, the only scorch area sample of the main Shroud from which material was analyzed with PMS, was sample 6BF (a blood flow sample, charachterized by Rogers as "light scorch").[271] This sample happens to be the sample on which Kohlbeck reported to have found a coating of starch.[272] That starch could be present and detected on this sample, means this starch needn't have been scorched/roasted in exactly the same way the Raes corner was – some Raes fibers showed no color with iodine at their surface[273], meaning that the starch had completely pyrolyzed to sugars and very small dextrins. So, on sample 6BF there needn't have been furfural from pyrolyzed hemicellulose either. Moreover, in the sample mapping, published by Schwortz, sample 6AF is labeled "Blood/Scorch Intersection", while sample 6BF is only labeled "Blood Flow".[274] Heller and Adler called sample 6BF "Blood image, front, lance area", while they called sample 6AF, taken closer to the scorch-patch than 6BF, "Blood-scorch image margin".[275] So, the actual fiber from 6BF that was tested with PMS, may not have been scorched at all. This could explain why the PMS-result from this sample didn't show the early high furfural/hydroxymethylfurfural ratio of the Raes sample.[276]
This questions the claim, made in 2005, that the Raes sample contained a pentosan contamination (from a pentosan plant gum, such as gum Arabic) and that the main Shroud samples did not.[277] Note, that if there are no pentosans on the main Shroud, this also excludes the presence of xylose from Saponaria, which soap extract could have given the cloth a superficial coating of free reducing sugars, but apparently didn't.

2.7. Lignin and vanillin

2.7.1. Raes sample – Vanillin: physics: no, chemistry: no inferences possible

Physical and chemical tests

Cardamone explained in 2000, that lignin is present in the cementing matrix, in which the linen cells are incrusted in a parallel configuration; a figure showed that lignin is present lengthwise along many, but not all, microfibrils inside a flax fiber.[278] She also says that lignin "is naturally brown in color and conveys light beige to brown coloration. It has been speculated that the Shroud fabric was not bleached [2]. Had bleaching occurred, lignin would have been whitened, not necessarily removed."[279]
Rogers explained: "A phloroglucinol-hydrochloric-acid reagent detects vanillin ... with great sensitivity. Fresh lignin evolves vanillin in the reagent. You can often smell the vanillin that is evolved from the lignin of warm pine-tree bark. The lignin loses vanillin with time and temperature. The lignin on older samples of linen gives progressively weaker tests for vanillin as age increases."[280] From 1982 to 2005, Rogers wrote about lignin and vanillin of the Shroud in seven of his texts. Only in his 2003 article, published in Melanoidins, and in his 2005 article, published in Thermochimica Acta, he speaks explicitly about a chemical lignin test on the Raes sample, but ambiguously.

<table>
<tr><td>1982</td><td>In 1982, Rogers and Schwalbe wrote about pyrolysis mass spectrometry (PMS): “Mass spectrometry was run by pyrolysis of the samples. … There is a significant difference between the Shroud and the modern-primitive samples. The latter were found to contain lignin. This result was not entirely unexpected, because independent microscopic examinations of the modern-primitive samples had revealed lignin with the phloroglucinol/hydrochloric acid test, although the same test showed none on the Shroud samples.”[281]</td></tr>
<tr><td>2001</td><td>In 2001, his article in the BSTS Newsletter 54 gave a table with the percentage of counted “rings” that seemed to have a lignin color, when a sample was viewed under the microscope:
<table>
<tr><th>SAMPLE</th><th>% RINGS WITH LIGNIN</th><th>% RINGS WITH HEAVY</th></tr>
<tr><td>Modem Commercial</td><td>55 total, very light</td><td>None</td></tr>
<tr><td>Repeat Commercial</td><td>57 total, very light</td><td>14 light</td></tr>
<tr><td>Edgerton "Primitive"</td><td>86 total</td><td>36</td></tr>
<tr><td>Raes Thread #5</td><td>40 total, light</td><td>None</td></tr>
<tr><td>1FH, Holland cloth</td><td>60 total, fight</td><td>5 moderate</td></tr>
<tr><td>Repeat Holland cloth</td><td>73 total</td><td>7 moderate</td></tr>
<tr><td>1HB, Rt. Foot, dorsal</td><td>54 total</td><td>15 moderate</td></tr>
<tr><td>Repeat 1HB</td><td>40 total, very light</td><td>None</td></tr>
<tr><td>3AF, Middle Finger</td><td>7 light</td><td>None</td></tr>
<tr><td>Repeat 3AF</td><td>80 total, light</td><td>7 moderate</td></tr>
<tr><td>Repeat 3AF</td><td>All clean</td><td>None</td></tr>
<tr><td>1EB Ankle, dorsals</td><td>All show lignin, most light</td><td>17 moderate</td></tr>
<tr><td>1IB, Scorch control</td><td>39 total</td><td>11 moderate</td></tr>
<tr><td>6AF, Side wound</td><td>40 (small sample)</td><td></td></tr>
</table>
His comment was: “The table shows that modern linen, the Raes samples, and the Holland cloth are all very similar in their amounts of lignin. There is probably no significant difference among them, other than the fluorescence of the modern type. In order to make an accurate test for significance, a very large number of observations are needed. This is terribly laborious and hard on the eyes: I do not plan to attempt a significance test. The fibrils observed on the Shroud tapes vary greatly in the amount of lignin that can be observed. A large number of measurements show that lignin ranges from heavy to nil, depending primarily on the location from which the sample was taken. This result was expected. ... I believe it is quite clear that the material of the Shroud is significantly different from both the Holland cloth and the Raes sample from 1973.”[282]</td></tr>
<tr><td>2002</td><td>In 2002, Rogers and Arnoldi wrote “A phloroglucinol-hydrochloric-acid reagent detects vanillin ... with great sensitivity. ... The lignin on Shroud samples does not give the test.”[283]</td></tr>
<tr><td>2003</td><td>In 2003, Rogers and Arnoldi wrote, after referring to their article of 2002: “Linen fibres in the Raes sample show at the microscope only traces of lignin at the nodes in comparison with the rest of the Shroud, indicating a more modern technology for cloth preparation, which is confirmed by the chemical quantitative determination of lignin.”[284]</td></tr>
<tr><td>2004</td><td>In 2004, the answer to “Frequently Asked Questions” no. 13 reads “The lignin in the Shroud does not give the normal microchemical test for vanillin, indicating that it is quite old.”[285] The answer to question no. 15 reads “A very sensitive microchemical test exists for the detection of traces of vanillin. ... no test can be obtained from the few Shroud fibers that are still available for study.”</td></tr>
<tr><td>2005</td><td>In January 2005, Rogers’ Thermochimica Acta-article was published: “The lignin at growth nodes on the shroud’s flax fibers (Fig. 1) did not give the usual chemical spot test for lignin (i.e., the phloroglucinol/HCl test for vanillin). The Holland cloth and other medieval linens gave a clear test.” (p. 190)[286]
Further in the text he wrote: “The Raes threads, the Holland cloth, and all other medieval linens gave the test for vanillin wherever lignin could be observed on growth nodes. The disappearance of all traces of vanillin from the lignin in the shroud indicates a much older age than the radiocarbon laboratories reported.”, and still further in the text: “No samples from any location on the shroud gave the vanillin test.” (p.191).[287]</td></tr>
<tr><td>2008</td><td>Rogers’ book, “A Chemist’s perspective on the Shroud of Turin”, posthumously published in 2008, reads: “The photomicrograph of image fibers in Chapter VI shows dark deposits at the growth nodes of the linen. I assumed that these spots were lignin that was not removed during the bleaching process. Modern linen that has been bleached with chlorine or other active bleaches shows some very small black specks at growth nodes. I thought that an abundance of lignin would give evidence for primitive technology. A very sensitive test for lignin can be found in the scientific literature. It uses phloroglucinol in concentrated hydrochloric acid to produce and react with vanillin from the lignin. The positive response is a vivid violet color. The Shroud fibers did not give the test. The small specks of black on modern linen did not give the test; however, the black deposits at the growth nodes on fibers from the Shroud's medieval backing cloth (the "Holland cloth") showed clear positive tests. Other medieval samples we had gave a clear test. A sample from the wrappings of the Dead Sea scrolls did not give the test, but that is not a place I would want to live without air conditioning. ... No samples from any location on the Shroud gave the vanillin test.” (p. 40-43).[288]</td></tr>
</table>

First of all, the Shroud samples analyzed by PMS included material from Raes thread #3,[289] which according to the 1982 article did not contain lignin. So, “the Shroud samples” – mentioned in this

same article – that showed no lignin in the phloroglucinol test, may also have included a Raes sample. On the other hand, as in 1982 there was still no suspicion or controversy about anomaly of the Raes corner, perhaps no Raes thread was chemically tested for lignin before 1988.

In the 2008 book's "CHAPTER VII: CHEMICAL TESTS" (pp. 36-46), Rogers speaks about chemical results from "Raes threads" on p. 37 and 39, when discussing protein and pentoses, respectively, but says nothing explicit about results from Raes threads, when discussing lignin or vanillin (p.40-43). This suggests no chemical test for lignin (and vanillin) was done on Raes threads, unless the Raes corner was meant and included in the last sentence "No samples from any location on the Shroud gave the vanillin test." (p. 43). A clue is that the book's "CHAPTER IX: THE RADIOCARBON SAMPLE" (pp. 62 -76) discusses microscopically estimated lignin percentages, but says nothing about a chemical lignin and vanillin test. So, it seems as if the Raes threads weren't chemically tested for lignin, and that no lignin was chemically detected on the entire Shroud. Another clue is that in Rogers article of 2002, in his section "I. The Radiocarbon Date of 1988", where the Raes threads are thoroughly discussed, the chemical lignin test is mentioned – "The lignin on Shroud samples does not give the test." –, but nothing is said about a result from Raes threads.[290]

A reason for not testing the Raes threads may have been that the team that did the lignin test on Shroud samples, the Holland cloth (the Shroud's medieval backing cloth), and other medieval linen – the "we" of "Other medieval samples we had" p. 43 – didn't have any Raes samples then. Rogers' 2005 article says he received the Raes threads from Turin on "14 October 1979",[291] although an earlier work says he received them in 1980[292]. Rogers' "we" of p. 43 seems to refer to the STURP team, that met and did chemical tests in Colorado Springs in January 1980.[293] Indeed, in their article, published in 1981, Heller and Adler of the STURP team reported to have found no lignin in their phloroglucinol/HCl test on sticky-tape samples; they also reported "the samples that we received for study are given in Table 1", and showed a table that only lists 22 specific sticky-tape samples from the main Shroud and its medieval backing cloth and one of its medieval patch cloths but no Raes sample.[294] The entire article doesn't list or mention any Raes sample. Heller, in his book of 1983, reported that he and Adler did the lignin test in Connecticut, when they returned from the Colorado Springs meeting. Also in Heller's entire book nothing is said about a Raes sample, but the book does say that Heller and Adler, besides the 22 sticky-tapes, had a medieval Spanish linen, and did control tests on it.[295] Rogers, on the other hand, had the Raes samples, but it seems he didn't have any medieval linen, that didn't belong to the sticky-tapes. If he would have had such a linen, he probably would have used it in his comparison of estimated lignin contents of various samples of linen, reported in 2001.[296] The only medieval linen he mentioned in this quantitative comparison, was a sticky-tape sample from the Holland cloth (the medieval backing cloth of the Shroud). So, the "we" that actually did the described lignin test, probably were Heller and Adler in 1980-1981, who had no Raes threads then.

The expression in the January 2005 article "The Raes threads, the Holland cloth, and all other medieval linens gave the test for vanillin wherever lignin could be observed on growth nodes" is ambiguous, and may imply that the STURP team could not observe lignin or growth nodes on Raes samples at all – simply because they had no Raes samples.[297] The only possibility that a lignin test was done on Raes threads, is that Rogers did the test himself, after his article of 2002 had been written and before he wrote his Thermochimica Acta article of January 2005.[298] But then, its result is still strikingly missing in his 2008 book. Perhaps Antonacci's comments (of June-July 2005) on Rogers Thermochimica Acta article,[299] was an inducement to rephrase Rogers' arguments on lignin for his posthumous 2008 book, by ommitting a result from Raes threads entirely.

Note, that an important complication is that Rogers, not being able to observe colored lignin in the bleached Reas threads in unpolarized light[300], in polarized light probably misunderstood dislocations – only visible in the crystal structure of flax fibers in polarized light – for "growth nodes", and thus didn't really test lignin in "growth nodes" either, but only realized this after he had done the lignin test, without positive result. This would be consistent with the 2005 article's separate remark, that is exactly the same and as separate as in the 2008 book (except for the missing capital in "shroud"): "No samples from any location on the shroud gave the vanillin test."

Note that in 2003 Rogers still said that "the chemical quantitative determination of lignin" confirmed "a more modern technology" for the Raes sample. This is another ambiguous statement: was lignin chemically tested, and/or just counted as observed black colored spots? "a more modern technology" means the linen was more thoroughly bleached,[301] leaving less colored lignin. In fact, if a chemical test was done, it probably didn't detect any lignin/vanillin at all, for if a chemical test had detected it, Rogers certainly would have reported it in 2003, clearly and immediately, as it would have been an absolute and more distinct difference with the main Shroud than just a relatively different quantity of observed black colored (lignin) spots.

Not necessarily "growth nodes"

In 2008, Svensson published the dislocation-growth node misunderstanding, in his article based on Fanti's file section of the Shroud Science Group. "Cross polarized light clearly demonstrates characteristic cross striation in flax fibers. By some au-thors this striation has been named *growth nodes*.(8) However, striation originates from mechanical stress and humidity levels either during growth, harvesting or post harvesting processing.(9) Conse-quently, in this paper striations are denoted *dislocations* instead of kinks, kink bands, nodes or growth nodes. (8 Raymond Rogers was convinced that these structures were growth nodes. This statement has been questioned, cf. the literature review by José Botella-Munoz, *An attempt to understand the so called "growth nodes" in flax fibers*, SSG file section: *José*.)"[302] The Raes corner, like every other Shroud corner, was excessively handled through the centuries, so dislocations, caused by mechanical stress, must be present here much more abundantly than in the main Shroud.

Not necessarily lignin

1) According to Cardamone, lignin is present lengthwise along many, although not all, microfibrils inside a flax fiber.[303]

2) No positive lignin test was received from black spots in main Shroud fibers or black spots in modern linen fibers; only the Shroud's medieval backing cloth and other medieval linen gave a positive lignin test.

3) Some or most of the black spots seen by Rogers on Raes fibers[304] possibly were scorch spots (scorched cellulose inside the medulla - compare with scorched Shroud fibers[305]) or roasted starch flakes on the fiber surface (compare with a flaked Ghost of a ligth-scorch Shroud fiber[306]),[307] as the Raes corner belonged to a water stain and light-scorch area.

4) Antonacci interestingly argued that the dark spots – in figure 6 of Rogers' 2001 article more present in image fibers than in non-image fibers – are possibly an effect of irradiation with protons, deuterium and alpha particles.[308]

Counted percentages not representative, or different, or significant

The 2001 article gave a table with the counted percentages of growth nodes with lignin in different samples (see above). First of all, the numbers probably aren't representative for the lignin amount in the two cloths. It seems that mere dislocations were counted as "growth nodes", of course without dense lignin. In the corners of the Shroud, also in the Raes corner, the fibers were much more handled than in the main Shroud. So, the mechanical stress of the handling would have caused much more dislocations in the corners, than in the main Shroud. So, the percentage of "growth nodes" (including dislocations) without lignin would be much higher in the corners. And the dark spots counted as lignin may not even have been lignin. Secondly, the numbers in the 2001 table don't show a difference between Raes and main Shroud samples. In fact, the only observation on a Raes thread ("Raes thread #5": "40 total, light" and "None" with heavy deposits) is the same as the observation on one of the main Shroud samples ("Repeat, 1HB": "40 total, very light" and "None" with heavy deposits). So, the remark in Rogers' 2008 book about a difference, "Differences among amounts of lignin on linen fibers in the Raes and radiocarbon samples and on Shroud fibers are significant",[309] isn't supported by the numbers of 2001. Thirdly, also the significance of this supposed 'difference' is not supported by the observations, for the 2001 article said no significance test was or would be done.

2.7.2. Main Shroud – Vanillin: physics and chemistry: no

"A very sensitive microchemical test exists for the detection of traces of vanillin. ... no test can be obtained from the few Shroud fibers that are still available for study."[310]
Also the sensitive physical analysis by pyrolysis mass spectrometry showed that the main Shroud samples contained no detectable lignin – the vanillin-evolving substance.

2.7.3. Comparison: both showed no vanillin

As only a few fibers from the main Shroud were chemically tested, and the result, or even occurrence, of a chemical test on lignin in the Raes sample is not conclusive, no conclusion can be drawn from the chemical tests. Pyrolysis mass spectrometry showed that neither main Shroud samples nor a Raes sample contained detectable lignin.

2.8. Fluorescence

2.8.1. Main Shroud – background fluorescence greenish-yellow

The main Shroud shows a weak greenish-yellow background fluorescence in UV-light, in areas that don't belong to the body image, blood stains, and scorches.[311]

2.8.2. Raes corner with dirt and lightly scorched – different fluorescence

Flury-Lemberg wrote that "the area around the removed sample and the preserved corners display discolorations as big as human palms: blackish deposits under which the fibers appear to be sticking together. These coatings - obvious to the naked eye - are clearly in contrast to the surface of the rest of the shroud, fig.15. But they do not have their origins in added yarns used in darning or inweaving, as has been postulated, they are simply greasy dirt. This is a plausible explanation in view of the fact that innumerable unwashed hands have handled the shroud whenever it was shown in the past."[312]

2.8.3. Comparison: different fluorescence is normal

The very fluorescent substance squalene[313] – one of the constituents of dirt from human hands – plus the quenching of the fluorescence by the rest of the dirt, plus the fact that the Raes corner is a light-scorch area, may have caused the discoloration of this corner in fluorescence in comparison with the background fluorescence of the Shroud.[314]

Verwijderd: UV-vis
Verwijderd: UV-vis

3. Repair?

3.1. Textile experts: no repair

Flury-Lemberg, conservator of the Turin Shroud, wrote "Though the Turin shroud is burdened with the dust of centuries and with greasy dirt deposits on the corners, fig.15 - a result of the countless handlings in the past – its weaving structure is cohesive and untouched even at the corners. Therefore at no time has the need to reinforce the corner parts arisen! ... the late Gabriel Vial, confirmed repeatedly that the sample was taken from the original cloth! This affirmation seems to be unacceptable to a natural scientist even if it comes from such an excellent textile scholar as Gabriel Vial who moreover made this judgment in his very own field of expertise. In any case, neither on the front nor on the back of the whole cloth is the slightest hint of a mending operation, a patch or some kind of reinforcing darning, to be found, fig.17 and 18." ("17.) and 18.) Detail of the shroud, front and back, showing the area where the sample was taken. The woven material displays the irregularly spun threads of the warp and the weft – well-known features of an antique textile -, but not the slightest hint of a mending operation.")[315] Marino and Benford wrote "In 2003, Flury-Lemberg's book about the restoration was published. Once again she denied that it would have been possible for an invisible reweave to have been added to the Shroud. She asserted that such a procedure would be visible on the reverse side of the fabric (Flury-Lemberg 2003:60)"[316]; "At the international Shroud conference held in Dallas in September 2005,

we informally presented that and additional information about the invisible reweave. Flury-Lemberg was at the conference and again maintained that an invisible reweaving would be detectable on the reverse side."[317]

Woven on a loom

Heimburger published a photograph, showing some Raes threads as received by Rogers, and added "From the above photograph, we can see that some threads are straight (for example Raes #1) while some others show "*distinct, periodic bends. They correspond to the 1:3 spacing of the weave, and they were compressed into the yarn segments. They are almost certainly weft yarns. The straight segments are almost certainly warp yarns (…) which were held under tension during weaving*" (from Rogers, SSG message # 574)."[318] The observed indentations in weft threads and absence of indentations in warp threads prove that the Raes threads were woven on a loom and not locally applied one by one and interwoven, because only if the warp threads were strung up and tautened on a loom ("held under tension during weaving"), they could have had the higher tension needed to create the observed indentations in the lower-tension weft threads. Also the weft thread F15001, taken from the main Shroud adjacent to the Riserva, shows these 'loom-indentations'.[319] To priorly weave a piece of repair linen on a loom, with exactly the same number of warp and weft threads per cm as in the rest of the Raes corner of the Shroud, seems impossible to do. Anyway, invisible mending – i.e. invisible on the front and reverse side – is claimed to have been done by applying threads one by one: "Today, there is a modern, time-saving technique called "inweaving: that would be invisible from the surface, but easily recognizable from the back. However, the technique used in sixteenth century Europe called "French weaving" is an entirely different matter. French weaving involves a tedious thread-by-thread restoration that is, indeed, invisible. Sixteenth century owners of the Shroud certainly had enough material resources and weeks of time at their disposal to accomplish the task (Balsiger and Minor, 2007:159)."[320]

Raes sample: ancient cotton spun-in

Raes reported that the traces of cotton fibers he observed in some preparations of the Raes sample, showed about 8 reversals per cm, corresponding to the cotton type Gossypium herbaceum, an ancient Egyptian cotton.[321] Also Rogers found this type of cotton in Raes threads, and reported that the fibers were spun with the linen.[322] "Both kinds of fibers have been spun together to obtain the thread."[323] This precludes a medieval repair.

3.2. Physics: no repair

"Morris et al. reported relatively uniform concentrations of calcium and strontium in all of their spectra (see note 6). ... Heller and Adler [37] have since postulated that the calcium and strontium were absorbed into the linen during the retting process (in which case the elements would be detectable with x-rays but not with the tape surface samples)."; "6 ... thirteen threads, removed from non-image, non-blood areas of the Shroud in November 1973 [41], were brought to America following the Turin study. X-ray fluorescence measurements were made on these with isotope sources of ^{55}Fe, ^{109}Cd, ^{145}Sm, and ^{57}Co for counting periods of 500-1000 min. These results showed roughly the same relative concentrations of calcium, strontium, and iron that were observed in the original 1978 Turin data."[324] Jackson and Antonacci explain this result from the 1973 Raes threads is "a compelling argument that the fabric of the radiocarbon site is very likely not due to a fabric that is alien to the Shroud."[325]

Referring to the paper of Schwalbe and Rogers, "Physics and Chemistry of the Shroud of Turin" in Analytica Chimica Acta 1982, Jackson wrote: "Another piece of evidence can be seen by considering Figure 7 of the above Analytica Chimica Acta paper, which shows a 1978 radiograph of what would be ten years later the site of the radiocarbon sampling. The authors Schwalbe and Rogers in 1982 concluded that the side strip must be of the same material as the main body of the Shroud because alternating high and low material density bands, that probably correspond to different weft lots, can be seen propagating across the seam that joins the side strip to the main Shroud. This argument can also be applied to test the hypothesis of a reweave. If a reweave has

occurred, then surely the continuity of the radiographic bands would be disrupted at the reweave intersection with the Shroud because the reweaved fabric would have different radiographic properties. Such a discontinuity is not observed anywhere in the Figure 7 radiograph, and therefore we must conclude unambiguously that there has been no reweave whatsoever surrounding the radiocarbon sample site."[326]

And as already mentioned, "the FTIR data for the radiocarbon sample, … shows physical characteristics of both the waterstain and scorch regions of the cloth."[327] That the carbon dating sample would be less homogeneous chemically than the main Shroud, is not proved, for only at RC fiber level there was much variability, because a fiber from a single RC thread can be either: - cotton or linen, - with a very thick, or very thin, or no coating, - scorched or unscorched, - with or without dirt deposit, because a fiber can be either from the inside of the thread, from the outside of the thread, from the top of the weave, or from the intersections of the weave. This may vary even along the length of a single fiber. The only-top-of-the-weave surface fibers from the main Shroud sticky-tape samples, on the other hand, "were removed from the tape, and their identity as to type verified": Adler picked and cleaned 5 fibers of the non-image type, 4 of the waterstain type, 4 of the scorch type, 2 of the serum-coated type, 2 of the image type, etc.[328] No wonder that the FTIR spectra of a type were identical. E.g., a chosen and cleaned non-image non-scorch non-waterstain fiber from the sticky-tapes, is only linen, with a very thin coating, unscorched and without dirt deposit. Of course there were spectral differences between the types.

3.3. "Spliced thread"? – partly inside the rolled hem

Raes thread #1 (R1, probably a warp thread because it shows no weave indentations[329]) appears to have two differently looking ends: one end looks tight and yellow, and the other end looks fuzzy and white.[330] It has been assumed that two different threads had a twisted overlap (had been twisted together, or 'spliced' together) to form one single thread, in order to invisibly repair the Shroud with medieval threads, one by one.[331] Both ends were examined with XPS, producing High Resolution Spectra, and the result, reported by Villarreal in 2008 and written on one of his presentation slides, was that "The two ends are chemically similar".[332] Moreover, the spectra of both ends were comparable to the spectrum of cotton, also in FTIR analysis; and dispersive X-ray fluorescence showed that the thread had the unexpected Si throughout its whole length.[333]

Obvious objections against the 'splice' hypothesis are the following: Why splice a cotton thread to a cotton thread in order to repair a linen Shroud? Why 'invisibly' splice a white thread to a yellow thread, as the color difference would be visible anyway?

The most simple explanation for the two different ends of Raes thread #1 is, that one end of the thread was inside the rolled hem of the Raes sample, and the other end was just on the outside of the hem (see fig. 3) (or one end had been folded into the folded seam, and thus was inside the seam, and the other end was in the outer part of the long seam of the Shroud). In FTIR analysis, also other threads of the Raes sample (R7 and R14) looked like thread R1 (i.e. like cotton with a resin contamination), and Villarreal said the problem was that there was no age-dated linen standard available: "we don't have a standard that is age-dated like the Shroud is – the main Shroud". In FTIR analysis, even a purported main Shroud thread (Tama 4 thread) appeared to be "not a good match for either the cotton or linen standards. This may be the result of aging effects or the material may be something entirely different".[334]

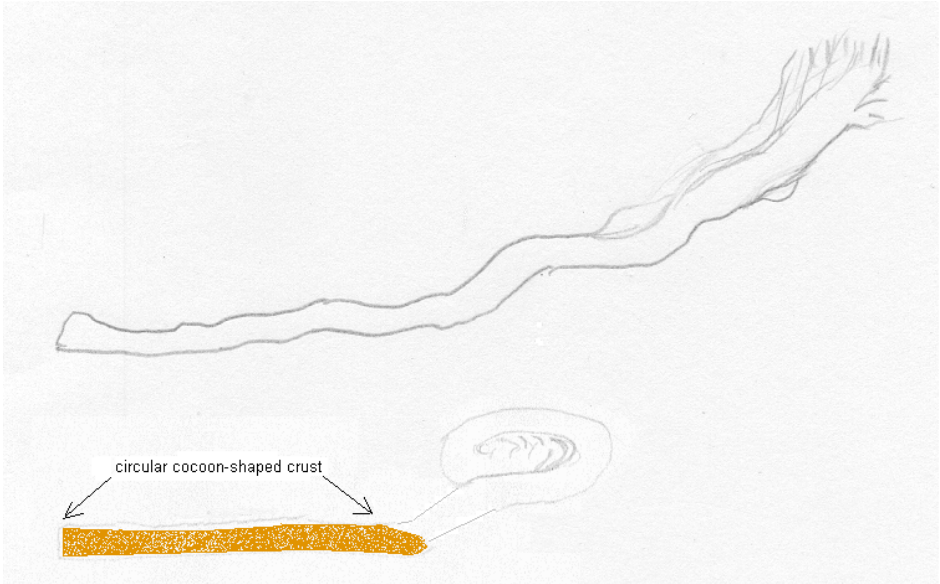

Fig. 3 Scetch of Raes thread R1 and the way it may have been rolled up in the hem

When the Raes corner was slightly scorched, the inside of the hem may not have been scorched at all. When the Raes corner was handled through the ages, the inside of the hem did not collect dirt. And even when the cloth was dipped into the cold Madder solution at the end of manufacture, the dye probably didn't reach the inside of the rolled hems and folded seam of the thightly woven and starched cloth. The dye did not get into the threads but only reached the surface fibers of a thread: only the surface fibers of a Raes thread have the yellow-brown starch-dye coating – fibers from the inside are nearly colorless.[335] Moreover, "The Shroud cloth is tightly woven, it is relatively thick, and it does not readily absorb water." [336] And the cotton in the (probably more tightly woven) selvedges retained a thicker starch coating and thus would be more cold-water thight than the cotton-poor and starch-poor main part of the Shroud. So, a rolled hem in a selvedge area probably did not get soaked with the dye throughout.
Raes, who unraveled the woven sample to threads, didn't report to have seen a 'splice', and the reason most probably was that he knew the provenance of thread R1 – viz. the hem – and had naturally interpreted the yellow/brown color of the outer end simply as dirt from centuries of handling, and the white color of the inner end as lack of this dirt.

Crust on Raes thread #1: "terpene based resin"
As already described above (2.5.1.), the broken off "micro-sized circular cocoon-shaped brown crust" that seems to have neatly encompassed only the tight end of Raes thread #1 (see fig. 3, and the same length of the broken off tight end (region 2) and the broken off crust, shown in Villarreal's photograph)[337], "appeared to be an organic-based resin, perhaps a terpene species, with cotton as a main sub-component."[338] Starch and Madder are both organic, and the observed deposit of dirt from the excessive handling of the Raes corner,[339] would contain human squalene, which is a triterpene.[340] Alizarin and purpurin of Madder resemble a terpene, because they have a limited number of hydroxyl groups (-OH groups) in comparison with cellulose.[341]

3.4. Horizontal sewing thread? – sinusoïdal sewing thread

Another suggestion for the way a repair could have been made, is that a patch was stitched to the longitudinal seam of the Shroud.[342] An argument that was used for a stitched-patch hypothesis, is the difference between a continuous dark line below the seam in the sample area, and the two rows of black horizontal marks along the seam outside the sample area, seen on an X-ray photograph of the Shroud.[343] It was hypothesized that the black lines represent stitches made with a linen thread and that the stitching of the original seam was done differently than the stitching for the attachment of the patch to the seam in the sample area. This interpretation is not plausible, for the

stitches of the original seam were two rows of overhand stitches, and were not looking like a black intermittent line but like a white sinusoidal (S-shaped) line on another X-ray of the seam.[344] The two rows of overhand stitches were illustrated in a drawing and characterized as a first-century Jewish type of stitching ('Masada-type') by Flury-Lemberg,[345] and they can be observed online via Shroud Scope.[346]

3.5. Anomalous sewing thread? – exactly similar yarns

The argument that the 2-ply sewing thread of the seam has an S-twist, and the Shroud's warp and weft threads have a Z-twist, doesn't constitute an anomaly, but rather a confirmation of the contemporaneous manufacture of cloth and sewing thread, for to obtain a strong, balanced, 2-ply thread two Z-twisted yarns need to be plyed together in a S-twist.[347]

3.6. Vertical seam? – continuous float

A next argument was that "a subtle vertical seam" would be visible, where the patch might have ended and the original cloth began.[348] But this tiny unevenness may be nothing more than a slightly protruding thinner weft thread or flaw in the weave. The float of the sample area – i.e. the variation of thick and thin warp threads[349] – is continuous across the 'vertical seam' at the end of the 'patch',[350] so this precludes that a patch ended here. Also the weft threads in the Riserva are visibly continuous across the border between the 'patch' and the original cloth, supposed warpwise at the triangular turn of the herringbone weave pattern.[351]

3.7. Dyed patch without visible water stain? – not discolored and with stain

If the 'patch' was applied and dyed in the 16th century to resemble the color of an undyed old Shroud, then the aging in the following centuries would have caused a color difference between the two areas. The color of the dye on the patch would have slowly disappeared, rendering the patch lighter in color. The linen of the Shroud, on the other hand, would have become more dark through further aging. So, the resulting difference in color would have made the existence of a patch visible in the 20th and 21st century. The photograph in Sindone 2002 doesn't show such a patch-discoloring, but does show "the edge of the water stain and the rest of the water stain extending into part of the radiocarbon site".[352]

It was suggested that on the photograph of the 'Riserva' of the radiocarbon sample no waterstain can be discerned that should/could have been there if the waterstain of a neighbouring area had been continuous in the sample.[353] In fact, in this photograph, an irregular darker yellow color can be seen on the right part of the 'Riserva'.

4. Implications

4.1. No anomalies – no repair

The absence of proteins and denatured proteins on the carbondating area precludes the presence of gum Arabic, which contains glycoproteins. The gum crust on the Raes and carbondating corner needn't be anomalic, but probably is the Shroud's overall starch-and-dye film, that, in this corner, was contaminated with deposits of handling dirt and was roasted to starch gum. Also the other so-called differences aren't anomalic (see the table below).

'Differences'	**Raes and carbondating area** (waterstain and light-scorch and contaminated area containing selvedge, seam and hem)	**Main Shroud**
A brown/yellow gum crust with starch	Thicker starch coating on cotton fibers, roasted to a flaked crust of starch gum (without proteins, so no gum Arabic)	Thinner flaked yellow crust found on light-scorch linen fibers, not chemically tested. Starch impurities detected. No not-blood proteins detected.
Pentoses or furfural	Detected (probably furfural from scorched hemicellulose)	Detected: positive test from scorched fibers, negative test from normal background: implicating no pentosan impurities, but furfural from scorched hemicellulose
Madder dye (alizarin and purpurin)	Chemically detected	Not chemically tested, but can account for the greenish-yellow UV-fluorescence of the background (max at 435 nm). Alizarin and purpurin fluoresce in the correct wavelengths (violet and yellow). Pectins don't fluoresce.
Madder lakes (aluminum oxide and calcite particles	Occasionally found as red and blue particles, so not used as deliberate mordants for a yellow (piece of) cloth	Madder lake particles identified, but less than 15 particles per sticky tape sample. Not chemically analyzed.
Aluminum	Abundantly present because of water stain bounded by seam and missing corner	Present in much smaller quantities because water stains are unbounded.
Lignin	PMS did not detect lignin. No significant difference in biased visual counting.	PMS did not detect lignin. No significant difference in biased visual counting.
Vanillin	Chemical test: unresolved	Chemical test: no vanillin
UV-fluorescence	Diffuse discoloration as big as the palm of a hand due to dirt with squalene and scorching	Light background fluorescence
Cotton fibers	Ancient near-eastern cotton spun in (10-20%) to create a strong selvedge at seam and hems.	Traces of spun-in cotton contamination (2%) outside of selvedges
'spliced' thread	Differently colored thread ends because of thread provenance from rolled hem	No differently colored thread ends, for no sample threads were taken from hem

The folowing facts preclude an invisible repair:

Visible	No visible patch-discoloring or loose threads or frayed ends in cloth
	Similar 'loom-indentations' in weft threads
	Similar Z-twisted basic yarn in weave and 2-ply sewing thread
	Continuous float in warp and weft
	Ancient Egyptian cotton spun in
Physics	Continuous radiograph
	Similar relative concentrations of calcium, strontium and iron found in X-ray fluorescence measurements
	Similar FTIR as scorched waterstain, and not necessarily less homogeneous
	Fluorescence: C14 site in midst of scorch mark and at the edge of a water stain

Verwijderd: UV-vis

4.2. No reducing saccharides but transformed starch: no Maillard reaction

For a Maillard reaction to be able to produce a body image on a cloth putrifaction gases from a corpse (amines) and reducing sugars or reducing dextrins need to be present in a sufficient amount and concentration. For a gas to be able to produce a doubly superficial image, as on the Shroud,[354] the reducing reagents also would have to be present only on the topmost parts of the fibers of the cloth, on both sides of the cloth. Otherwise, a gas that permeated the cloth would have reacted with the reagents on the more inner parts as well. For the Shroud, it has been suggested that reducing sugars from Saponaria officinalis (soapwort) and reducing small dextrins from starch were present very superficially due to the exsiccation of the washing products.[355]

4.2.1. Starch uniformly distributed through the cloth

1. In 2004, Fanti reported "the first SEM analysis of the linen fibers coming from the Shroud: the external coating due to polysaccharides (and probably crude starch) does not show a structure typical of an exsiccation product. If so a uniform distribution along the cloth thickness of the saccharides must be supposed and then the superficiality of the body image is very questionable in the gas diffusion hypothesis."[356]
2. The photograph of the 'splice' shows that the coating is all around the thread at the tight end of the 'splice'.[357] The photomicrograph of many fibers from the Raes thread from glas vial #5 shows a starch coating on all of the many fibers in the field of vision.[358] The photomicrograph of fibers from Raes thread #5 shows a starch (gum) coating all around the fiber surface.[359]
3. The lubrication of warp and weft threads with starch during weaving would have resulted in a distribution of starch throughout the thickness of the cloth, not only on the top of the waeve. All starch probably wasn't suspended in the water when the cloth was washed to remove most of the starch. The absence of free amylose and the presence of other starch fractions (iodine test) seems to confirm this.

4.2.2. No sugars from Saponaria

There was searched for evidence for free sugars, or other chemical products from the soapwort Saponaria officinalis on the Shroud, but none was found.[360] So, there is no evidence for the presence of reducing sugars from Saponaria. Note that Saponaria doesn't contain reducing dextrins.

4.2.3. No reducing dextrins from starch

It is possible that the Shroud's linen threads were lubricated with a cooked starch paste before weaving, although there is no text of Pliny the Elder describing the use of this technique.[361] Today starch products are (still) used for warp sizing.[362] The presence of starch on the Shroud was reported by several researchers (see above). The question is now whether there could have been any reducing saccharides – such as small dextrins – from starch on the Shroud immediately after manufacture.

Refined crude starch

Unrefined crude wheat starch contains pentosans and soluble gluten proteins as main contaminants.[363] Pliny the Elder (77 AD) described an ancient method of refining crude wheat starch, by frequently washing with fresh water, filtering through linen cloth, and then fermenting with leaven.[364] A fact is that in 1978 there were no detectable pentosans and non-blood proteins on the Shroud, even in non-scorch areas.[365] This means that there is no detectable starch pentosan or soluble gluten protein either. So, most of the pentosans and gluten protein and other soluble starch contaminants would have been washed out and fermented out of the crude starch at starch manufacture, before it was cooked and applied as a lubricant for the weaving of the Shroud. So, at this point there were no small reducing dextrins in the crude starch.

Cooked starch paste

Small reducing dextrins are only produced by breaking the large starch molecules (amylose and amylopectin) into much smaller pieces by applying enzymes or dry heat (120 °C in

concentrated acidic environment, or 180 °C in a dilute acidic environment).[366] Pliny the Elder described how a fine starch paste was made by cooking wheat flour with "some small drops of vinegar": only this fine starch paste was fine enough for paper making, as "the ordinary workman's paste will render the paper brittle". [367] Cooking crude starch in water (100 °C) without vinegar would not produce any dextrins at all. Cooking crude starch in water with some drops of vinegar would perhaps produce some dextrins, but these would be only large dextrins, that, just as amylose and amylopectin, are not reducing.[368] So, also after cooking and applying a starch paste there would be no reducing dextrins on the Shroud.

Washed starch coating

Afer weaving, the starch paste cooled down and became a stiff coating of (retrograded) starch. The cloth was washed in warm water to largely remove this coating. The low-molecular-weight starch fractions would have washed out first (amylose and any large dextrins). After washing, the remaining starch film would have consisted of the high-molecular-weigth amylopectin and retrograded amylose. This starch film would have been the binder for the Madder dye, in which the cloth was dipped. So, also immediately after manufacture there would have been no small reducing dextrins on the Shroud.

Roasted starch film

At the fire of 1532 AD, in some Shroud areas, the starch film was subjected to dry heat, which changed the starch into starch gum, consisting of pyrodextrins. Pyrodextrins of starch gum (British gum) do not reduce Fehling's solution.[369] The size of pyrodextrins depends on the pyrolysis conditions and pyrolysis time.[370]

This reconstruction is consistent with the reddish color that was observed when iodine was added to Shroud fibers. The iodine tests on the Raes samples didn't show a blue color (from single helix amylose) but a red color, which proves the presence of amylopectins and/or retrograded (double-helical) amylose and/or relatively large dextrins.[371] An amylose molecule that, on cooling down in the starch paste, had retrograded by forming a double helix with another amylose molecule or with an amylopectin molecule, had lost its capacity to include iodine and to form a blue iodine color.[372] Rogers said that when they were "testing for sulfoproteins in blood areas with an iodine-azide reagent (it bubbles vigorously when sulfur is present), we got a reddish background".[373] This sounds as if the red color was not (only) on the microscopically observed fiber but in the background of the field of vision of the microscope, and thus that the product that colored red with iodine, was (also) in solution or suspension. Dextrins are cold-water-soluble, [374] and, according to some, so is amylopectin.[375] Retrograded starch is not, but it may have been suspended in the bubbling iodine-azide solution – Rogers and Arnoldi suggested that amylose caused the observed reddish color.[376]

If the observation was made in a scorch area, the observed reddish color may just have resulted from large pyrodextrins, formed when starch (amylose and amylopectin) was changed into dextrins by pyrolysis (decomposition by dry heat) during the fire of 1532. If the observation was made in a non-scorch area, the absence of a blue color proves the absence of single-helix amylose in the suspension and on the fiber. This means that this amylose either had all retrograded in the stiffening cloth after weaving, or that any remaining single-helix amylose had been washed out of the cloth with warm water at the end of the manufacture, or retrograded to double-helical amylose after washing and drying.[377] If the (large) single-helical amylose was washed out at manufacture, also small reducing dextrins – if ever present – were washed out. The reddish color could only have been formed by amylopectin or retrograded (double-helical) amylose or large not-reducing dextrins. Small reducing dextrins do not give a red color with iodine, but leave the (yellow) iodine color unchanged.[378] The unspecified remark in Rogers' posthumous book, that "Reducing saccharides have been detected on the Shroud", is simply incorrect. [379]

Note that Rogers did say correctly, when discussing the 'half-tone' effect of the image: "The color density seen in any area of the image appears primarily to be a function of the number of colored fibers per unit area rather than a significant difference in the density of the color of the fibers. … Diffusion of gaseous reactants or dyes into the cloth would have produced a color gradient (darker on the surface, lighter at depth)."[380]

4.2.4. Starch transformed by image formation

Where image color is present on a fiber, it is uniform all around the circular surface of the fiber, but it needn't be present all along the length of the fiber.[381] Heller and Adler deliberately tested image-type fibers – i.e. completely colored fibers – for starch, and didn't detect it.[382] Rogers incidentally found traces of starch fractions when "testing for sulfoproteins in blood areas".[383] Here, the tested fiber was possibly from a blood/image area, but it was not necessarily a completely image-colored fiber. The detected starch fractions may have been present on a not-colored length of it, perhaps even under the blood. Rogers added: "we should have tested for starch", so he didn't do any specific tests for starch on specific fibers then. His remark in a later work[384] "The hypothesis on carbohydrate impurities is supported by observations of traces of some starch fractions on image fibers" gives no specification or reference, so he may still have meant his incidental find. Rogers' 2008 book[385] says McCrone "had found wheat starch on the Shroud", but also here there's no reference. Kohlbeck perhaps found starch on sample 6-BF from the lance wound area, i.e. a blood/image area.[386]

If Heller and Adler accidentally only tested image-type fibers that never had starch (never applied well, or abraded before image formation), a Maillard reaction is precluded immediately: it can not color pure linen. In the other case, Heller and Adler's observation proves that, where starch was colored, it was completely transformed by the image formation process. A Maillard reaction can not do this either.

Verwijderd: peak shift

4.2.5. Fluorescence reduction by transformed Madder dye

In UV fluorescence, the Shroud shows a banded appearance that is continuous through the image: where a background band is darker also the image is darker.[387] This needn't be the result of a band-dependent image formation process, such as a Maillard reaction on a banded layer of reducing saccharides. It can be simply explained by the 'half-tone' effect of the image itself (i.e. that the image is made up of separate, colored fibers of the same color in a background of not colored fibers, as in a pixel image).[388] Image formation quenched the UV fluorescence of only the colored fibers: the fluorescence of the not colored fibers in the image would have remained the same, representing the properties of the background band they belong to. The banded appearance simply 'shines through' the image via the non-image fibers in it. The same applies to the appearance in visible reflectance.

Verwijderd: peak shift in the UV-vis

Verwijderd: alizarin of

Verwijderd: at 'Peak shift'

The reduced intensity of the fluorescence of image araes (and mottled looking areas), when compared to normal background areas,[389] however, is most easily explained by fluorescent Madder dye that was present on top of the fluorescent lignin and that was transformed in the image formation process (see 2.3.2.). A Maillard reaction – only possible between reducing saccharides and amino acids[390] – could not have transformed the fluorescent non-saccharide alizarin of fermented Madder root extract.[391] If alizarin was still part of an unfermented glycoside of Madder, this glycoside would not have been reducing either, for the glycosidic bond substitutes the reducing end of a sugar,[392] and a Maillard reaction could not have affected the alizarin. So, also the reduction of the fluorescence in image areas and mottled looking areas seems to preclude a Maillard reaction as image formation process.

Verwijderd: peak shift in the UV

Verwijderd: of

4.2.6. No additional nitrogen in image areas

Berry said in June 2012, that a "Maillard mechanism would require the image areas to have additional nitrogen, i.e. as ammonia or as volatile organic amines ("putrescine", "cadaverine" etc)", and that Rogers published the following that "effectively falsified" the Maillard hypothesis: "The pyrolysis-mass-spectrometry analyses of individual fibers at the NSF Center of Excellence at the University of Nebraska was sufficiently sensitive to detect ppb levels of polyethylene oligomers that came from sample bags, but it did not detect any of the possible pigments or painting media. The pyrolysis-MS analyses did not detect any nitrogen-containing contaminants. This seemed to rule out glair (egg white) as well as any significant microbiological deposits. These results were confirmed by microchemical testing."[393]

4.2.7. Maillard reaction precluded

Conclusively, there is no evidence for a pre-fire presence of reducing sugars from Saponaria (or from Madder) or of reducing dextrins from starch on the Shroud. The absence of pentosans and non-blood proteins on the Shroud even preclude the presence of small reducing saccharides from starch, because starch pentosans and soluble gluten proteins apparently were washed out of the crude starch, and so would have been small reducing saccharides, if they were ever present in it. Cooking crude starch in water, even with some drops of vinegar, doesn't produce small reducing dextrins or sugars. The absence of reducing saccharides on the Shroud would preclude the possibility that a Maillard reaction produced the Shroud's body images. So would completely transformed starch, and a fluorescence peak shift caused by transformed Madder dye. The absence of additional nitrogen in image areas effectively falsifies the Malliard hypothesis. A uniform starch distribution through the Shroud, and other obvious inconsistencies between the Shroud's body images and a Maillard reaction by gas diffusion have already been published by Fanti in 2004.[394]

4.3. Planned internal selvedge and one-time uniform dye: First-century Pharisaic temple mantle

The following sequence of markings of the Turin Shroud (as John Mark's temple garment[395]) can be drawn from the previous analysis of data:

time/event	**result**
pre-weaving	cotton-linen spun together (deliberately for selvedge threads and as contamination for main Shroud threads)
	cotton-linen on loom for warp selvedges (at edges and for seam) and in certain weft batches (for hems)
weaving	starch paste applied for lubrication
post-weaving	cloth warm-water washed
	cloth dyed with Madder without mordant
	cloth cut at internal selvedge and perfectly stitched together again (seam)
	hems rolled and stitched
wearing	curved creases
burial	blood stains
(Resurrection)	body images (absent inside chin crease)
removing of mantle-identification marks	two corners cut off asymmetrically
storing in Essene jar	large water stains from cold water
handling and showing	dirt deposits in corners
1532 AD fire	scorching and small water stains
handling and showing	more dirt deposits

Pyrodextrins (soluble starch gum) are in the large water stain area – so, the soluble pyrodextrins were formed from starch after the water reached the area, and the water reached the area when it still had insoluble starch – the water was cold for it didn't remove the insoluble starch: cold water reached the cloth before the fire of 1532 AD (cf. Gueresschi[396])

The bounded waterstain has a higher salt concentration – The missing corners were already missing before the pre-1532 (probably first-century) waterstain in the Raes corner was made.

The seam was stitched before the hems were and the internal selvedge for the seam was woven before the seam was: internal selvedge and seam are planned original features of manufacture, probably for a **Pharisaic mantle with enlarged border**.

The seam nearly perfectly rejoined two pieces that had been one piece: That the seam joins two separate pieces of cloth has been revealed by the Shroud's conservator Flury-Lemberg in 2000, showing a photograph of an unstitched part of the seam and a drawing of the way the seam

had been stitched.[397] Nevertheless, the seam looks continuous in every weft thread, as has been concluded from the X-radiograph of the Shroud including side-strip.[398] A. and M. Whanger, after examination of the radiographs of the seam, even said in 2005 that the seam appeared to be a tuck, because of its "near perfect alignment" and "the absence of any frayed thread ends along either side of the seam".[399] This near perfect match means that the two pieces of cloth probably had been continuous before the manufacturer cut a strip from the Shroud. He/she then must have meticulously reattached it right when and where it was cut, without cutting away another longitudinal part of the cloth.
The seam thus was unnecessarily but deliberately planned to be in the cloth, which can simply be explained by a Pharisaic meticulous effort to literally obey Num 15,38, which says that a margin had to be put on every robe.[400] The cloth was woven and cut and sewn in order to produce a **Pharisaic mantle with enlarged border**.

Dyeing didn't wash out/smear the blood. The image was formed after the unsmeared and unbroken blood stains got unto the cloth[401] – so, the dye solution was applied before blood staining and image formation occured.

Dyeing didn't add fluorescence to the image. The image and blood stains do not fluoresce, the rest of the cloth does: the image formation quenched the linen(-starch-)dye fluorescence – so, the starch/dye was applied before blood staining and image formation occured.

Madder dye without (yellow) mordant on starch binder – so, the very expensive white mantle would never get washed after manufacture (if it would, the first hot wash would wash out the starch–and-dye coating, and a cold wash would not remove the dirt that got into the starch) – so, it probably was not allowed to be washed, because it was a **Jewish temple garment,** necessarily manufactered before the destruction of the Jewish temple in 70 AD.

5. Discussion

The physical, chemical, and microscopical data of the radiocarbon sample area show no signs of a repair or inexplicable differences with the main Shroud, and even indicate that the sample area and main Shroud are one cloth and that this cloth most probably was a first-century Jewish temple garment. As an invisible 16th-century repair of the Shroud seems to be precluded, another explanation of the reported medieval radiocarbon date of a first-century cloth might be found. Antonacci reported an experiment showing that ancient linen is radiocarbon-juvenized by neutron irradiation.[402] Di Lazzaro reported experiments showing a Shroud-like coloration of linen can be created by VUV-irradiation.[403] Fanti reported experiments showing that a Corona Discharge (an electrical discharge naturally accompanied by particle- and VUV-irradiation) can create Shroud-like images, which fit the characteristics of the Shroud's superficial body images better than (results of) all other proposed image formation processes do.[404] Di Lazzaro invited Ramsey, director of the Oxford Radiocarbon Accelerator Unit, to collaborate in a team to study the Shroud's radiocarbon dating results.[405] Such a collaboration could produce very interesting insights.

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[1] This thesis has already been defended in another article, where it was based on other Shroud charachteristics: A.A.M. van der Hoeven, "The seam and missing corners of the Turin Shroud as characteristics of John Mark's temple garment", http://www.jesusking.info/The%20seam%20and%20corners.pdf

[2] http://en.wikipedia.org/wiki/Linen

[3] This is a hypothesis of Rogers, Comments on, p. 12. On the other hand, "It has been speculated that the Shroud fabric was not bleached [2]. [2] Flury-Lemberg, M., The Shroud Fabric: Technical and Archeological Characteristics, The Turin Shroud Past Present and Future, International Scientific" (Cardamone, p. 147)

[4] This is the hypothesis of Rogers, Comments on, p. 12; starch is (still) used for a "warp sizing paste": http://www.nicstarch.com/Html/Product_Conversion_001.htm (2-1. Oxidized starches and 2-2. Oxidized starch esters)

[5] "the first **SEM analysis** of the linen fibers coming from the Shroud: the external coating due to polysaccharides (and probably crude starch) **does not show a structure typical of an exsiccation product.** If so a uniform distribution along the cloth thickness of the saccharides must be supposed and then the superficiality of the body image is very questionable in the gas diffusion hypothesis. This study is in progress." (Fanti, Comments on gas, p. 1.)

[6] Maimonides, Mishneh Torah, Kli Hamikdash, chapter 8, Halacha 4-5:

"Halacha 4 It is a mitzvah for the priestly garments to be new, attractive, and to hang low like the garments of the men of stature, as [implied by Exodus 28:2 which states that they must be made]: "for honor and for beauty." If they were soiled,16 torn,17 longer than his appropriate measure,18 shorter than his appropriate measure, hoisted up by the sash,19 and a priest performed service while wearing them, his service is invalid.20 If they were worn-out or they were too long and he hoisted them with the sash so that they would be appropriate to his measure, his service is valid. (17: The commentaries have drawn attention to an apparent contradiction in the Rambam's words, for in *Hilchot Bi'at HaMikdash* 1:14, he rules that, after the fact, when a priest performs service in torn garments, although he is liable to die at the hand of heaven, his service is acceptable. Among the resolutions offered is that here, the Rambam is speaking about clothes that remain torn. Hence, it is as if he is no longer wearing that garment. In *Hilchot Bi'at Hamikdash*, by contrast, he is speaking about torn garments that were mended. As the Radbaz explains (in his gloss there), the Rambam is speaking about a tear like the tear made when one rends his garments in mourning which can be mended. Here, he is speaking about a garment that was torn in many places.)

Halacha 5 Whenever any of the priestly garments become soiled, they are not bleached or laundered. Instead, they are left to be used for wicks and he should wear new ones.21 (21: For there should be no expressions of poverty in a place of wealth (*Zevachim* 88b))." (Maimonides, Mishneh Torah, Kli Hamikdash, chapter 8, Halacha 4-5, http://www.chabad.org/library/article_cdo/aid/1008233/jewish/Chapter-8.htm)

Maimonides, Bait Hamikdash, halacha 14-15 and 17:

"Halacha 14 The laws [applying to a priest who enters the Temple with] torn garments are the same as those [applying to one with] long hair, as [Leviticus 10:6] states: "Do not let [the hair on] your heads grow long or rend your garments lest you die."40 Thus if [a priest] served with torn garments, he is liable for death at the hand of Heaven although his service is valid and was not profaned.41

(41: This ruling appears in direct contradiction to Hilchot K'lei HaMikdash 8:4 where the Rambam writes: "If [the priestly garments] were muddy, torn, longer than his appropriate measure... and a priest performed service while wearing them, his service is invalid." Among the resolutions offered is that in Hilchot K'lei HaMikdash, the Rambam is speaking about clothes that remain torn (therefore, even after the fact, the service is invalid), while here he was speaking about torn garments that were mended. As the Radbaz explains, here the Rambam is speaking about a tear like the tear made when one rends his garments in mourning (which can be mended) as indicated in the following halachah, and there, he is speaking about a garment that was torn in many places.)

Halacha 15 It appears to me42 that any priest who is fit to serve who enters the area of the altar or [proceeds] beyond there43 while intoxicated due to wine, drunk due to other alcoholic beverages, with long hair, or with torn garments as one tears because of a person's death, he is liable for lashes, even if he did not perform service. [The rationale is that] he is fit for service and entered [the Temple] at the time of service in such an unkept manner although he was warned not to enter.)

…

Halacha 17 Similarly, it is forbidden for any person, whether a priest or an Israelite, to enter the entire Temple area, from the Courtyard of the Israelites and onward46 when he is intoxicated from wine, drunk [from other beverages], with unkept long hair or with torn garments. Although there is no explicit warning [against this in the Torah], it is not a sign of honor or reverence47 to the great and holy house to enter it unkept. If, however, an Israelite48 lets his hair grow until it is formed into a weave and it was not unkept, he is permitted to enter the Courtyard of the Israelites.49" (Maimonides, Mishneh Torah, Bait Hamikdash, halacha 14-15 and 17, http://www.chabad.org/library/article_cdo/aid/1008242/jewish/Chapter-1.htm)

[7] Strong's H8336 *shaysh, shesh-ee'* (The second form for alliteration with H4897); for H7893; *bleached* stuff, that is, *white* linen or (by analogy) marble: - X blue, fine [(twined]) linen, marble, silk. Easton's Bible Dicitonary, Linen: "Heb. shesh; rendered "fine linen" #Ex 25:4 26:1,31,36 etc. In #Pr 31:22 it is rendered in Authorized Version "silk," and in Revised Version "fine linen." The word denotes Egyptian linen of peculiar whiteness and fineness (byssus)." http://www.biblestudytools.com/dictionaries/eastons-bible-dictionary/linen.html

[8] Morrish Bible Dictionary, Linen: "Various Hebrew and Greek words are translated 'linen,' and there can be no doubt that linen made of flax was known in ancient Egypt and to the Israelites; but cloths generally are called 'linen' whether made of cotton or flax, some being distinguished as 'fine linen,' such as was worn by the priests, kings, &c. The word *shesh*, often

translated ‘fine linen’ and ‘fine twined linen’ (for the curtains of the tabernacle, &c.) signifies ‘whiteness,’ and is applicable to both fine linen and cotton. Ex 26:1,31. Joseph was arrayed in ‘vestures of fine linen.’ Ge 41:42. The wrappings on the ancient Egyptian mummies were for a long time judged to be cotton, but by the use of the microscope they have been discovered to be linen.” (http://www.stempublishing.com/dictionary/473_500.html)

[9] Online Bible Hebrew Lexicon 08336 ‘shesh’ = 1) something bleached white, byssus, linen, fine linen 2) alabaster, similar stone, marble.

[10] Pliny the Elder, Natural History, 19, 2: “The upper part of Egypt, in the vicinity of Arabia, produces a shrub, known by some as "gossypium,"[26] but by most persons as "xylon;" hence the name of "xylina," given to the tissues that are manufactured from it. The shrub is small, and bears a fruit, similar in appearance to a nut with a beard, and containing in the inside a silky substance, the down of which is spun into threads. There is no tissue known, that is superior to those made from this thread, either for whiteness, softness, or dressing: the most esteemed vestments worn by the priests of Egypt are made of it.” 26 “Our cotton, the Gossypium arboreum of Linnæus. See B. xii. c. 21. The terms *xylon, byssus,* and *gossypium,* must be regarded as synonymous, being applied sometimes to the plant, sometimes to the raw cotton, and sometimes to the tissues made from it. *Gossypium* was probably the barbarous name of the cotton tree, and *byssus* perhaps a corruption of its Hebrew name.” (http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.02.0137%3Abook%3D19%3Achapter%3D2).

[11] 2006 Smith’s Revised Bible Dictionary - LINEN : “3. B-ts, {c} ({c} זוּר, βυσσος, byssus) always translated "fine linen" except, {#2Ch 5:12} is apparently a late word, and probably the same with the Greek βυσσος, by which it is represented by the LXX It was used for the dresses of the Levite choir in the temple, {#2Ch 5:12} for the loose upper garment worn by kings over the close-fitting tunic, {#1Ch 15:27} and for the vail of the Temple, embroidered by the skill of the Tyrian artificers. {#2Ch 3:14}”

[12] Easton’s Bible Dictionary: Linen: “Heb. buts, "whiteness"; rendered "fine linen" in #1Ch 4:21 #1Ch 15:27 2Ch 2:14 3:14 Es 1:6 8:15 and "white linen" #2Ch 5:12. It is not certain whether this word means cotton or linen.” http://www.biblestudytools.com/dictionaries/eastons-bible-dictionary/linen.html . ‘buts’ Strong’s H948: From an unused root (of the same form) meaning to *bleach*, that is, (intransitively) *be white*; probably *cotton* (of some sort): - fine (white) linen.

[13] “The priests could not place their priestly garments under their heads to serve as pillows, for they were forbidden to derive benefit from them. See Yoma 69a. In his commentary to Tamid, Chapter 1, Mishnah 1, the Rambam explains that this prohibition was instituted because the priestly garments contained Sha'atnez, a mixture of linen and wool. Hence, though a priest was permitted to use them during the Temple service, once that service was concluded, he was forbidden to do so. See also the Kessef Mishneh.” (Maimonides, Mishneh Torah, Beis Habechirah 8, footnote 29, www.chabad.org/dailystudy/rambam.asp?tDate=9/30/2021#footnoteRef29a1007193)

[14] Maimonides, Mishneh Torah, Kli Hamikdash 8, halacha 11-12 (http://www.chabad.org/library/article_cdo/aid/1008233/jewish/Chapter-8.htm)

[15] The probable course of events is described in A.A.M. van der Hoeven, The seam and missing corners, and in A.A.M. van der Hoeven, John Mark, both on www.JesusKing.info .

[16] e.g. “Only a single sample was taken and that was from a most unsuitable location, i.e., from the edge of a bounded waterstained scorch area … .” Adler, Chemical and Physical Aspects, p. 25.

[17] http://en.wikipedia.org/wiki/Dextrins

[18] “The thickness of the coating on the Raes yarn varies greatly. Cotton fibers tend to have much thicker coatings than linen fibers; however I would guess that the coating does not average more than about 2microm thick.” Rogers and Arnoldi, Scientific Method, p. 27

[19] “the coating on the Raes samples can easily be observed with a normal light microscope with sodium-D light; however, it can easily be missed when normal procedures are followed. (index close to that of immersion oil, slide) … It can be completely invisible on a normally prepared slide.” Rogers and Arnoldi, Scientific Method, p. 27

[20] Excerpts from the 1973 Commision Report, p. 25, point 13 (temporarily published on the internet by the Holy Shroud Guild in 2011). The dimensions of the original sample are not well defined. Van Haelst said in 1999 that the video of the cutting of the C14-sample showed it was an irregular triangle of 6.1 x 1 cm (Van Haelst, Radiocarbon dating, p. 14) . The photograph published by Heimburger (Cotton in Raes, part 3, p. 3), in which the weft threads can be counted, and the density of weft threads in the C14-reserve-sample, counted by Vercelli (Rinaldi, Autogol a Tucson, p. 1), suggest the dimensions of the triangle were about 36-38 mm x 11-13 mm. The photograph of the Raes corner, when the C14 sample had been cut, but the background of the Raes sample was still visible on the backing cloth, suggests the length of the Raes sample was 32-33 mm plus the length that was covered by the blue edge. When the jagged long edge of the Raes sample, as in Heimburger’s photograph, is compared to the edge of the corresponding missing side strip in the Enrie photograph (http://www.dshroud.com/shroudScope/shroudScope.shtml?zl=11&image=1&lon=572&lat=2415.5), it seems the edge of the Raes sample was about 36-38 mm long.

[21] Heimburger, Cotton in Raes, part 3, p.1: “According to Raes himself, his sample consisted in 3 main pieces: - Piece 1 (about 40mm x 13 mm) from the main Shroud. - Piece 2 (about 40 mm x 10 mm) from the “side strip”. - And the two-ply yarn used to sew together the two pieces. This means that this heavy linen yarn was in fact made of 2 individual threads, each being wound round the other.” Raes published his report in (“La S. Sindone”-Supplemento Rivista Diocesana Torinese, gennaio 1976)

[22] Raes, The textile study of 1973-1974. Citation copied from Heimburger, Cotton in Raes, part 1, p. 1, which also reads: “From this observation, it was widely assumed that Raes Piece 1 was representative of the main part of the Shroud: the Shroud appeared to be basically linen (flax fibers) with “traces of cotton” of Gossypium herbaceum variety.”

[23] Marino and Prior, Chronological History, p. 24
[24] Marino and Prior, Chronological History, p. 24
[25] Tyrer, Looking at the Turin Shroud, text and photograph of observe side of the Raes sample on p. 22
[26] "McCrone and Sox had inspected the sample (apparently unstitched by Raes into two pieces) during a visit with Raes in 1976, and found that "the samples were kept in what looked like an old scrapbook for postage stamps" (Sox: 1978:48)." Maecham, Radiocarbon Measurement
[27] Flury-Lemberg published a photograph of the seam, showing that, after the seam had been opened by removing one of the sewing threads, two cutting edges appeared, and she wrote "Sowohl die breite Stoffbahn als auch der angefügte schmale Streifen haben an einer Seite eine Webekante und an der jeweils anderen Seite eine Schittkante. Diese Schnittkanten beider Stoffabschnitte werden in der Längsnaht zusammengefügt." (Flury-Lemberg, Die Leinwand, Abb. 3 a, p. 34 and p. 23). (translation: 'Both the broad piece of fabric and the attached narrow strip have on one side a selvedge and on the other side a cutting edge. These cutting edges of both fabric sections are joined together in the longitudinal seam.')
[28] "STURP researchers reported that "The radiographic images substantiate the 4-5 mm width of the 'seam.' …"", Benford and Marino, Discrepancies, p.10
[29] Heimburger, Cotton in Raes, part 3, Fig. 15, p. 3
[30] Rogers, A Chemist's Perspective, p. 64 and fig IX-11 on p. 75
[31] For a scetch of the location of the respective samples, see Rogers, A Chemist's Perspective, fig. IX-1 p. 64
[32] Damon and Donahue et al., Radiocarbon Dating
[33] Van Haelst, Radiocarbon dating the Shroud of Turin – A critical review, Collegamento Pro Sindone, 2002, note 15, p.34-35. Idem in Wilson, Cotton on, pp.7-8
[34] Rogers, A Chemist's Perspective, p. 64
[35] Rogers and Arnoldi, Scientific Method, p. 14 and 17; "Figure 6 shows fibrils from Raes thread #5. ... You can see one cotton twist (lower right), but the field of view at 400X is too narrow to see any other twists. Twists are about 1.25mm apart. According to Raes, this would identify the cotton as *herbaceum*. Each major division of the reticule is 0.026 mm." Rogers, Supportive comments, p. 2 and fig. 6 on p. 5
[36] Heimburger, Cotton in Raes, part 3, p.1; Rogers declared to the Shroud Science Group: "I have found copious amounts of cotton at the core of all of the yarn segments I have dissected." Communique to the Shroud Science Group, March 5, 2004, 2:30 AM, cited in Marino and Prior, Chronological History, p. 18; cf. "Cotton is not a simple surface contaminant: It occurs throughout the Raes threads." Rogers and Arnoldi, Scientific Method, p. 14
[37] Heimburger, Cotton in Raes, part 3, p. 2
[38] Rogers and Arnoldi, Scientific Method, p. 14
[39] "Figure IX-3 shows fibers from the radiocarbon sample. The flat ones with a twist in them are cotton. Notice that both cotton fibers are completely covered by a colored layer. Some of the linen fibers are nearly clean. …The radiocarbon sample contains cotton, the fibers are coated, and the bleaching method was more efficient than that used on the main part of the Shroud." - "Figure IX-3: Cotton and linen fibers from a warp thread of the radiocarbon sample, 800X in 1.345-index oil." Rogers, A Chemist's Perspective, p. 66-67
[40] Heimburger, Cotton in Raes, part 3, p. 4-5 (emphasis of Heimburger)
[41] "The ToF-SIMS results were the first to show that the spectra from the two ends were similar to cotton rather than linen (flax) and the Spectroscopist recommended that the next analysis should be with the FTIR instrument. After several scans of individual fibers or strands, the FTIR data showed that the two ends (Region 1 and 2) were definitely cotton and not linen (flax). The crust appeared to be an organic-based resin, perhaps a terpene species, with cotton as a main sub-component. After showing the FTIR data to Barrie Schwortz and Sue Benford, they were quite surprised at the results and decided to send me two other pieces of thread (No. 7 and 14) that were from the same sampling area and that had been in John Brown's Lab in Marrietta, Georgia. The results of the FTIR analysis on all three threads taken from the Raes sampling area (adjacent to the C-14 sampling corner) led to identification of the fibers as cotton and definitely not linen (flax)." Villarreal, Analytical Results, Abstract. The twisted end showed more C (and N and Ca), and less O and Si, than the fuzzy end (see the video of Villarreal's presentation, at ca. 15:15, through the link http://www.shrouduniversity.com/videos/villareal.wmv on page http://www.shroud.com/ohioconf.htm#Conference).
[42] "Freer e Jull trovano tre fibre di cotone con le osservazioni al microscopio di alcuni fili nel loro frammento. … Non vengono esaminate le fibre di cotone per distinguere se si tratta di cotone del genere Gossypium, quello usato in tutto il Vecchio Mondo fino alla scoperta dell'America, oppure se si tratta di una varietà americana importata dopo Colombo. … Usano il microscopio a fluorescenza, senza fornire particolari sulla procedura, per dire che non c'è patina o tintura sul loro frammento." Rinaldi, Autogol a Tucson
[43] Heimburger, Cotton in Raes, appendix by Fanti
[44] Slides published by Bracaglia, Raes Problematic Threads, part 3
[45] Heimburger, Cotton in Raes, part 3
[46] "the slides we had gotten back from McCrone … There was one heck of a lot of debris present, both modern and ancient. … linen of different shades, tint, and degrees of corrosion, cotton, silk, wool, animal hairs, modern synthetic fibers of different types and colors, insect parts, tiny droplets of what appeared to be beeswax from church candles, modern fly ash, crystals, particulates of different sizes and shapes, dust, spores, pollens, and much material I could not identify without more study." Heller, Report on, p. 163
[47] Rogers and Arnoldi, Scientific Method, p. 15
[48] "I did not attempt to make a quantitative cotton comparison between Raes threads and Shroud tapes, because there was too little cotton of any kind on Shroud samples. We had been puzzled by the Raes report at the time of the 1978 STURP

observations in Turin. We could not find more than traces of cotton on the cloth. The Shroud appeared to be pure linen. We used cotton gloves during the STURP studies of 1978 to protect the relic, and they could have been responsible for the traces of modern cotton found on a few Shroud sampling tapes." Rogers and Arnoldi, Scientific Method, p. 15; cf. photgraph of STURP members on http://www.shroud.com/gallery/pages/4-M-4.htm

[49] Slide "Sticky Tape Sample from the Shroud Area" shows a yellow and white twisted flat fiber (dyed cotton?) and under it a half twisted white fiber (cotton?) (Photo upper left = white light; photo lower right = UV fluorescence); Slide "Sticky Tape Sample Indicating Flattened Fibers" shows some red flat fibers (dyed cotton?) and a yellow fiber (Villarreal, Video of his presentation Analytical Results, at ca. 30:57 and 32:02).

[50] Heimburger, Cotton in Raes, appendix by Fanti

[51] Heimburger, Cotton in Raes, part 3, p. 4

[52] Heimburger, Cotton in Raes, appendix by Fanti, p. 3

[53] Marino and Prior, Chronological History, p. 25

[54] Heimburger, Cotton in Reas, part 3

[55] cf. Rogers and Arnoldi, Scientific Method, fig. 10, p. 14

[56] Two pieces: Flury-Lemberg, Die Leinwand, p. 34, Abb. 3a; originally continuous: Adler and Whanger and Whanger, Concerning the Side Strip

[57] Rogers and Arnoldi, Scientific Method, p. 14

[58] Antonacci and Heimburger, Private Internet Debate, p. 32

[59] Rogers, Comments On, p. 12

[60] "Flax thread is not elastic so is difficult to weave without breaking threads." http://en.wikipedia.org/wiki/Linen

[61] Rogers and Arnoldi, Scientific Method, p. 20

[62] The solubility of these two starch components is not certain. A scientific article says it is just the other way around: "A survey of 22 popular organic chemistry textbooks showed that only four correctly stated that of the two components of starch, amylopectin is the water-soluble, and amylose is the water-insoluble. (MLH)" (Mark M. Green, et al., Which Starch Fraction is Water-Soluble, Amylose or Amylopectin?, Journal of Chemical Education, 52, 11, 729-730, Nov 1975, http://www.eric.ed.gov/ERICWebPortal/search/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=EJ128481&ERICExtSearch_SearchType_0=no&accno=EJ128481)

[63] Rogers, Comments On, p. 13-14

[64] Rogers and Arnoldi, Scientific Method, p. 7

[65] Rogers and Arnoldi, Scientific Method, p. 30

[66] Rogers, A Chemist's Perspective, p. 44

[67] Fanti and Schwortz et al., Evidences for testing, Fact A15

[68] Rogers, Frequently Asked Questions, p. 11; McCrone, Judgement Day for the Turin Shroud, p. 85

[69] In 2012, I interpreted the text on Kohlbeck's "observation" as applying to starch in the lance wound area, but now, on second thoughts, I think the "observation" in the lance wound area may be only the observed blackening effect of miscroscopy oil on red particles, not the observation of starch on Raes threads: Bracaglia of the Holy Shroud Guild wrote "Dr. Kohlbeck explained to me that Sue Benford contacted him and requested if he could send her his microscopic photographs of the lance wound area where Dr. Kohlbeck made his observation. (6-BF). She explained to him that she believes what Dr. Heller thought was blood is actually the gum,dye,mordant coating which Dr. Kohlbeck referred in his findings as Starch." (Bracaglia, Raes Problematic Threads, part 3)

[70] Only single-helical amylose can include the iodine ions in such a way that it colors blue (http://braukaiser.com/wiki/index.php?title=Carbohydrates#Reaction_with_iodine). Completely retrograded amylose has formed double helixes with other amylose molecules or amylopectin molecules: "The texture of heat-gelatinized starch mixtures is variable. Some gelatinized starch mixtures have a smooth creamy texture, while others are more pastelike. Some starches form gels after cooking and cooling. These starch gels may lack stability and slowly exude water through the gel surface. A similar breakdown of the gelatinized starch occurs in some frozen foods during thawing and refreezing. Although amylose is soluble in the hot gelatinized starch mixture, it tends to become insoluble in the cooled mixture. This phenomenon is called retrogradation and it occurs when the amylose chains bind together in helical and double helical coils. Retrogradation affects the texture of the food product and it also lowers the digestibility of the product." (http://www.encyclopedia.com/topic/starch.aspx)

[71] Heller, Report on, p.171

[72] Heller, Report on, p.198

[73] Heller and Adler, A Chemical Investigation, Table 7, p. 54

[74] The article, published by Heller and Adler, says "These test were performed on the uncoated fibrils: body-image, non-image and scorch fibrils" (Heller and Adler, A Chemical Investigation, p. 43). This is in contradiction with what Heller says in his book (Report on, p. 171 and 198), viz. that only image fibrils were tested for the listed organic substances. Also Heimburger (A detailed critical, p. 20) states: "Tests for the organic dyes: These tests were performed by Heller and Adler[47]on image fibers." (47 = Heller and Adler, A chemical investigation).
Besides, if only uncoated non-image fibrils were tested, the starch coating perhaps had remained in the adhesive of the sticky-tape, as the so-called "ghost" (see fact A3 of Fanti and Schwortz et al., Evidences).

[75] "Nothing other than dehydrated carbohydrate could be found in the image area." Rogers, Frequently asked questions, p.25

[76] Cellulose is a long chain, crystalline, polysaccharide, made of glucose units. "Starch and low-molecular-weight carbohydrates from crude starch would color much more easily than would cellulose as a result of either thermal

dehydration or chemical reactions." (Rogers, Frequently asked questions, p. 11). The primary cell wall of linen is 0,2 micrometer thick (Di Lazzaro, Sub-micrometer coloration, p. 18) – so about as thick as the "Ghost" of 200 to 600 nanometers thick –, and contains hemicellulose. Hemicellulose is a shorter chain, amorphous polysaccharide, made of several different kinds of sugar units. Just as retrograded cooked starch, it has much less strength than the crystalline cellulose of the cell body (medulla) (http://en.wikipedia.org/wiki/Hemicellulose)

[77] Heller and Adler, A Chemical Investigation, p. 43

[78] Rogers and Arnoldi, Scientific Method, p. 30

[79] Starch fractions on image fibers: Rogers and Arnoldi, Scientific Method, p. 30; "relatively long fibers show variation in color from non-image to image area (Fanti 2004)." Fanti et al., Evidences for testing hypotheses , B15

[80] Fanti et al., Evidences for testing hypotheses, fact B15.

[81] Rogers and Arnoldi, Scientific method, p. 6-7; the pyrolysis-mass-spectometry results were published in Schwalbe and Rogers, Physics and Chemistry, p. 14, and in Rogers, Pyrolysis/mass spectrometry (the table on p. 2 shows that Raes thread #3 and a thread from the heel (Zina-thread) were analyzed with PMS).

[82] Fanti and Schwortz et al., Evidences for testing

[83] Rogers, Frequently asked questions, p. 11

[84] See the quotation of Rogers' email, further in the text (from Carreira, The Shroud of Turin, p. 30)

[85] Fact A7 (Fanti and Schwortz et al., Evidences for testing) says "The colored layers in the adhesive have the same chemical properties as the image color on fibers (Rogers 2005)"; here "Rogers 2005" refers to Rogers, Studies on (nevertheless, this article doesn't say anything on the chemical properties of the image color, nor does it say the colored layers in the adhesive have the same chemical properties as the image color). Obviously, if the colored layer in the adhesive is/wass on fibers from all sorts of Shroud areas (Fanti and Schwortz et al., Evidences, fact A3), the image color can not be chemically completely identical to all colored layers in the adhesive, for then all fibers would have the image color, which is not true. Rogers wrote in 2004 "The color of image fibers was often stripped off of their surfaces, leaving molds of the fibers in the adhesive. Growth nodes can be seen in the molds. The colored layers show all of the same chemical properties observed on intact image fibers (see 12 above). All of the color is on the surfaces of the fibers. The colored layer is 200-600 nanometers thick." (Rogers, Frequently asked questions, p.16). So, Rogers did not say the "Ghosts" from all Shroud areas were chemically similar to the image color, for he only compared the stripped off color of image fibers with the color still on the intact image fibers.

[86] Jumper, Adler, and Jackson, et al., A Comprehensive Examination, p. 454

[87] "At magnifications up to 1000 X, these fibrils do not appear to have any coating. This is most clearly demonstrated by observations made at the joint locations of the linen fibrils. These joints exhibit no meniscus, but are clearly and sharply defined with no evidence of a coating. Further, under phase contrast microscopy, these fibrils not only appear uncoated, but show "corroded" surfaces as would be expected for an oxidatively degraded cellulosic material (12)." (12 = Heller and Adler, A Chemical Investigation) (Jumper, Adler, and Jackson, et al., A Comprehensive Examination, p. 454)
cf. Rogers: "No fibers in a pure image area were cemented together by any foreign material, and there were no liquid meniscus marks. These facts seemed to eliminate any image-formation hypothesis that was based solely on the flow of a liquid into the cloth." Rogers and Arnoldi, Scientific Method, p. 5

[88] "Positive fluorescamine tests were obtained on both the red and golden yellow coated fibrils" (Heller and Adler, A chemical investigation, The orphaned manuscript, p. 40); "These test were performed on the uncoated fibrils: body image, non-mage and scorch fibrils." (Ibid. p. 43).

[89] "14) The color of image fibers was often stripped off of their surfaces, leaving molds of the fibers in the adhesive. Growth nodes can be seen in the molds. The colored layers show all of the same chemical properties observed on intact image fibers (see 12 above). All of the color is on the surfaces of the fibers. The colored layer is 200-600 nanometers thick." (Rogers, Frequently Asked Questions, p. 16)

[90] Fanti and Botella et al., Microscopic and macroscopic; "200 nm (1 nm = 10^-9 m), i.e. the thickness of the primary cell wall of the single linen fiber." Di Lazzaro et al., Sub-micrometer coloration, p. 1

[91] Carreira, The Shroud of Turin, p. 30

[92] "By using a petrographic microscope we have observed some UV- and VUV-induced defects in the crystalline structure of irradiated linen fibers, showing analogies to those observed in image fibers of the Shroud." (Di Lazzaro and Murra, et al., Sub-micrometer coloration, p. 6); cf. VUV-irradiated uncolored medulla on p. 3.

[93] "Again there is no evidence of defects in the crystal structure of the cellulose in the medulla (dark area) showing that the CD does not act inside the fiber but only outside it." Fanti, Body Image Formation, Fig. 23, p. 16; "the CD cause effects in the crystal structure of the linen fibers one order of magnitude less than those present on the TS fibers." Ibid. p. 16; "No defects are experimentally obtained in the case of a CD coloration." Ibid. p. 4.

[94] Rogers, A Chemist's Perspective, p. 44

[95] "#25 Linen fibers also from TS and particles coming from "h" filter, Buttocks Area, 1978" , fig. 41, p. 19-20 in Svensson, Light microscopy study; its note 12 is "Cf. Leoncio Garza-Valdes' and Stephen Mattingly's interpretation in *The Turin Shroud, the Illustrated Evidence*, pp 95-103."

[96] Rogers and Arnoldi, Scientific Method, p. 20

[97] Nitowski, Criteria for authentication, p. 1

[98] Bracaglia, Raes Problematic Threads, part 1, Photo slide #41, showing the glass vial, numbered 5, with the 12 mm thread

[99] The third photomicrograph on http://holyshroudguild.org/dr-nitowski-new.html has the subscript "Discription made by Dr. Nitowski. Raes vial #5 sample Iodine stain indicates starch and illustrates pleochroism, north-south dark brown and east-west".

[100] Excerpts from the 1973 Commision Report, p. 23, point 1
[101] Excerpts from the 1973 Commision Report, p. 23, point 2
[102] "The next morning I phoned Kohlbeck and asked him if he had ever noticed the direction of the twist in the Raes sample. He said that he had not, but merely preformed the tests Rogers had requested. … I fully believe that Dr. Rogers is completely innocent in this matter. His insistence that Kohlbeck study the thread indicates that he was unaware that it was not genuine, since such action could only lead to eventual discovery. How Dr. Rogers obtained that particulate thread which is believed to be the 12 mm Raes sample, I don't know." Nitowski, Criteria for authentication, p. 2
[103] "Dr. Kohlbeck explained to me that he received the samples from Dr. Ray Rogers and was asked to photograph them." Bracaglia, Dr Nitowski's
[104] "I received 14 yarn segments from the Raes sample from Prof. Luigi Gonella (Department of Physics, Turin Polytechnic University) on 14 October 1979. I photographed the samples as received and archived them separately in numbered vials." Rogers, Studies on, p. 189-190; The photograph of the Reas threads as received by Rogers is shown as fig. 14 in Heimburger, Cotton in Raes, part 3, p. 2; it seems to me that the thread numbered 5 on the photograph is the same as the inserted colored thread with the thin yellow and white fuzzy end, called "Raes thread #1 showing an end to end splice" elsewhere by Rogers (Scientific Method, fig. 17, p. 21), and that the thread numbered 1 on the photograph in Heimburger looks a bit like the thread in vial #5 on Kohlbeck's slide, showing the glass vial, numbered 5 (Bracaglia, Raes Problematic Threads, part 1, photo slide #40). Also, in the photograph in Heimburger, the inserted thread with the subscript "14 mm" and with green arrows indicating weft thread numbered 11 on the photograph, seems to me not the same as this thread numbered 11. "Dr. Gonella explained further to Dr. Nitowski that he feared a possible switch with some or all of the Raes threads were possible." (Bracaglia, Raes Problematic Threads, part 1)
[105] Benford and Marino, Textile Evidence Supports, p. 11
[106] "The color instantly changed to bright yellow in 6N hydrochloric acid (HCl), and the coating was reduced in density as the fibers were soaked in the acid (figure 13). … Bright red lakes of dye were found on many of the most-colored Raes fibers, indicating that at least some Madder root dye was used and that some of the color appeared on a hydrous-aluminum-oxide mordant. … Hydrous aluminum oxide is instantly soluble in 6N HCl, and alizarin is bright yellow in acid (figure 13). Alizarin is used as an acid-base (pH) indicator in chemical analysis. It is yellow below a pH of 5.6 and red above a pH of 7.2 (figure 14), changing to purple above 11.0 (figure 15). This agrees with observations on the coating. Madder root dye is a highly probable contributor to the color of the coating. ... Many dyes show similar color changes with pH, and this observation should be confirmed with spectrophotometry and additional chemical tests. … Other mordants produce different colors with Madder, including blues with calcium compounds. A few blue lakes can be seen on Raes fibers. The color suggests traces of alizarin on crystals of calcite in the threads. They are all removed by 6N HCl. … In agreement with observations on the individual threads, I could not detect any significant amount of dye on fibers from the insides of threads." Rogers and Arnoldi, Scientific Method, p. 18-20
[107] http://en.wikipedia.org/wiki/Rose_madder
[108] http://stainsfile.info/StainsFile/dyes/58205.htm ; Wikipedia is incorrect in saying that purpurin becomes "yellow when dissolved with alkalis in boiling water" http://en.wikipedia.org/wiki/1,2,4-Trihydroxyanthraquinone, for Miliani et al. (2000) reported that purpurin "changes from yellow-orange (pH ≤ 3,5) to pink (pH≈ 6-9) to violet (pH ≥ 12)" in a water-dioxane solution, and that its pK_1 4.7, was "measured in mixed solvents, where the dielectric constant is reduced compared with pure water. However, the dielectric constant decrease for the mixture used [water-dioxane (2:1 v/v)], calculated by the empirical equation reported by Anderson, is relatively modest, hence the effect on the pKs does not exceed one pK unit." (p. 144, 148 http://onlinelibrary.wiley.com/doi/10.1002/(SICI)1099-1395(200003)13:3%3C141::AID-POC220%3E3.0.CO;2-J/abstract)
[109] Rogers and Arnoldi, Scientific Method, p. 18
[110] "Chemical tests on both the radiocarbon and Raes samples show their coatings to consist of a plant gum containing alizarin dye present in two forms. Some is dissolved in the gum, giving it a yellow color. A variable amount is complexed with hydrous aluminum oxide [AlO(OH)] to form red lakes (Fig. 3). The lakes are gelatinous and usually very small. … HCl (6N) brings the lakes into solution and turns bright yellow. … The solubility characteristics of the red lakes indicate AlO(OH). … The red dye/mordant lakes dissolved in 2N NaOH to give a purple solution. … Calcium compounds produce blue colors, and a few blue lakes can be seen on some gum-coated fibers. They are removed with 6N HCl. The color suggests alizarin on crystals of calcite or aragonite in the threads." (Rogers, Studies on, p.191-192)
[111] Freer-Waters and Jull, Investigating A Dated
Abstract: "We present a photomicrographic investigation of a sample of the Shroud of Turin, split from one used in the radiocarbon dating study of 1988 at Arizona. In contrast to other reports on less-documented material, we find no evidence to contradict the idea that the sample studied was taken from the main part of the shroud, as reported by Damon et al. (1989). We also find no evidence for either coatings or dyes, and only minor contaminants." (Note: The link to this abstract, https://digitalcommons.library.arizona.edu/util/login , was to a Subscriber's Only page without public access. The article "Evidence Is Not Proof: A Response to Prof. Timothy Jull" by Oxley, is a detailed response to Jull's paper, and so is the article by Rinaldi, Autogol a Tucson).
For a photograph of the sample, see the video of Killick et al., A visit to, at 1:23, 2:31 and 11:30.
[112] Rogers and Arnoldi, Scientific Method, p. 27
[113] "Cotton fibers tend to have much thicker coatings than linen fibers" Rogers and Arnoldi, Scientific Method, p. 27
[114] "Freer e Jull trovano tre fibre di cotone con le osservazioni al microscopio di alcuni fili nel loro frammento." Rinaldi, Autogol a Tucson

[115] McCrone, and Skirius, Light Microscopical Study; "McCrone's statement: "*On examining thousands of red image particles **on the Shroud tapes**, I saw no low refractive red particles except rose madder particles…*" 27; 27 = McCrone, Red ochre and Vermilion, www.freeinquiry.com/skeptic/shroud/as/mccrone.html" (Heimburger, A detailed critical, p. 13); "According to archaeologist Paul Maloney, Walter McCrone had sent him in 1981 several Kodak transparencies of photos he took of Shroud linen fibers. "On those slides, McCrone had written the following note: madder rose, linen fiber, medium (blue) sample 3 CB" and sample 3-AB. McCrone was referring to photomicrographs made on STURP sticky tape samples 3-CB and 3-AB which came from the blood flow across the back nearest the side-strip side of the Shroud and directly adjacent to that flow on linen, itself. … Regarding the presence of madder rose on the cloth, Maloney says, "There is now a new way of looking at the presence of that madder rose. Although this is some distance from the "Raes Corner" such trace amounts can now be conjectured to explain the dye that was used, along with the aluminum mordant and the gum Arabic as a binder to **create the wash to finish the re-weave.** Thus, it may now be seen not as a contaminant from an artist's studio, but rather a contaminant from the weaver's workshop." (Marino and Prior, Chronological History, p. 3-4)

[116] "McCrone had also mentioned that he had seen … wood charcoal and madder rose." (Heller, Report on, p. 189-190); "We examined every particle type we could find and tested it chemically, and could not corroborate any of his observations." (Heller, Report on, p.196)

[117] "A somewhat more serious type of contaminant is the occasional appearance of materials that can be clearly identified as artistic pigments such as rose madder or cinnabar, etc. … For a given tape, an arbitrary minimum threshold of 15 specimens of a particular type of visually identifiable characteristics (mainly color and surface appearance under phase contrast microscopy) was set to constitute a class of fibers of particles assignable to a specific location on the cloth to be subjected to chemical testing. … Carrying out this prescription excluded all the various types of contaminants discussed above and yielded 11 classes of sample objects or testing." (Adler, The Shroud fabric, p. 119).

[118] Adler, The Shroud fabric, p. 119; the discovery of an occasional cinnabar particle is described in Heller, Report on, p. 191-192.

[119] Fanti and Schwortz et al., Evidences for testing, Fact A3

[120] Heller and Adler, A Chemical Investigation, table 2, The orphaned manuscript, p. 50

[121] Heller and Adler, A Chemical Investigation, The orphaned manuscript, p. 35

[122] Heller and Adler, A Chemical Investigation, The orphaned manuscript, p. 43

[123] In the article A Chemical Investigation of the Shroud of Turin, Heller and Adler say (in The orphaned manuscript, p. 43) "These test were performed on the uncoated fibrils: body-image, non-image and scorch fibrils." This is in contradiction with what Heller says in his 1983 book Report on the Shroud of Turin, p. 171 and 198, viz. that only image fibrils were tested for the listed organic substances. Also Heimburger states: "Tests for the organic dyes: These tests were performed by Heller and Adler[47]on image fibers." (47 = Heller and Adler, A chemical investigation) (Heimburger, A detailed critical, p. 20)

[124] Fanti and Schwortz et al., Evidences for testing, Fact A3

[125] http://en.wikipedia.org/wiki/Alizarin and http://en.wikipedia.org/wiki/Purpurin_(dye)

[126] "They then found that Madder Lake contained two colorants, the red alizarin and the more rapidly fading purpurin. Purpurin is only present in the natural form of madder, and gives a distinctive orange/red generally warmer tone that pure synthetic alizarin does not. Purpurin fluoresces yellow to red under UV light, while synthetic alizarin slightly shows violet.[9] ='Les Rayons Ultra-Violet Applicques a l'Examen des Couleurs et des Agglutinants' Mouseion, 1933." http://en.wikipedia.org/wiki/Rose_madder

[127] Miliani et al., 2000, http://onlinelibrary.wiley.com/doi/10.1002/(SICI)1099-1395(200003)13:3%3C141::AID-POC220%3E3.0.CO;2-J/abstract

[128] http://en.wikipedia.org/wiki/Violet_(color)

[129] http://en.wikipedia.org/wiki/Blue

[130] "Figure VIII-2: Spectral fluorescence of four clear areas of the Shroud with excitation at 365 nanometers. Maximum fluorescence is at about 435 nanometers." Rogers, A Chemist's Perspective, p. 51

[131] Rogers, A Chemist's Perspective, p. 40

[132] Adler, Chemical and Physical Aspects, p.13. Adler referred to the publication of V. Miller and S. Pellicori, J. Biol. Photogr. Assoc., 49 (1981):71; Cf. Heimburger: "This is confirmed by the photos of the Shroud in the visible under pure UV illumination[14] (=V.D. Miller and S.F. Pellicori, J.Biol.Photograph.Assoc., 49 (1981) 71.). They show yellow-greenish background fluorescence, no fluorescence emission of the image (brown) and of the blood stains (dark brown to black spots) and the characteristic reddish orange fluorescence in the slight scorches." (Heimburger, A detailed, p. 7) Di Lazzaro and Murra et al. reported that the (modern) linen they used, emitted blue fluorescence under UV illumation: "Il tessuto di lino, come tutti i materiali organici, emette luce fluorescente blù quando è illuminato da luce UV." (Colorazione Simil-Sindonica, p. 14-15; cf. Di Lazzaro and Murra et al., Sub-micrometer coloration, p. 4)

[133] Adler, Chemical and Physical Aspects, Fig. 2, p.14

[134] http://www.cas.muohio.edu/~meicenrd/ANATOMY/Ch4_Histology/lab4.html; cf. Di Lazzaro et al., Colorazione Simil-Sindonica, p.14-15

[135] Miller and Pellicori, Ultraviolet Fluorescence, p. 77. and 80

[136] Miller and Pellicori, Ultraviolet Fluorescence, p. 75

[137] Gilbert and Gilbert, Ultraviolet-visible reflectance, p. 1935

[138] Miller and Pellicori, Ultraviolet Fluorescence, p. 83

Verwijderd: http://webbook.nist.gov/cgi/cbook.cgi?ID=C72480&Mask=400#UV-Vis-Spec

[139] "Areas in the weave where the image density abruptly decreases (e.g., sides of the face) might actually contain very faint images which possibly could be retrieved by using stimulating radiation of shorter wavelengths. The property of the linen thread that didn't develop image density should also be discovered." Miller and Pellicori, Ultraviolet Fluorescence, p. 85.
[140] Schwalbe and Rogers, Physics and Chemistry, p. 24
[141] "The background cloth shows a light greenish yellow emission not always seen in other known older linen cloths and perhaps suggesting the presence of some type of thin coating of a fluorophore such as pectic substances left over from the retting of the original linen." Adler, The Shroud fabric, The orphaned manuscript, p. 115
[142] Pellicori, Spectral properties, p. 1919. cf. Miller and Pellicori, Ultraviolet Fluorescence, p. 84
[143] Miller and Pellicori, Ultraviolet Fluorescence, p. 84
[144] Miller and Pellicori, Ultraviolet Fluorescence, p. 80
[145] "The absorbing water marks at 3 and B through E have light border areas." Miller and Pellicori, Ultraviolet Fluorescence, p. 76
[146] "The water mark above the knees at 18 has an absorbant edge with density gradations. Some fluorescing bordering can be seen also. In white light, however, this water stain is not prominent. The fluorescent color is brown as opposed to grey. The water stain situated above the series of holes to the right side has very little emission. Some of the water stains are better defined in fluorescence, others are not." Miller and Pellicori, Ultraviolet Fluorescence, p. 82
[147] Heimburger, A detailed critical, p. 7, refering to Morris, Schwalbe and London, X-Ray Fluorescence Investigation
[148] Rogers, A Chemist's Perspective, p. 20 - no reference to Pellicori's report is given here.
[149] Miller and Pellicori, Ultraviolet Fluorescence, p. 81
[150] Adler, Chemical and Physical Aspects, The orphaned manuscript, p. 14
[151] "Another feature requiring explanation is the lighter bordering areas seen with many bloodstained areas. The interpretation is that blood serum is present. It might have acted to retard the image development reactions associated with the body image." Miller and Pellicori, Ultraviolet Fluorescence, p. 85
[152] "The Gilberts observed that the image reduced the fluorescence of the underlying background and shifted the maximum slightly to longer wavelengths. They also found that this fluorescence reduction and maximum shift is produced by the scorches and to some extent by the mottling in the background areas. The fluorescence reduction is probably a combined result of several factors. A decrease in the areal density of fluorescent material would contribute, as would an attentuation of both incident excitation and emitted fluorescent radiation through the scorches and image. ... but the shift of the background fluorescence peak to longer wavelengths suggests that an attenuation of the emitted background fluorescent radiation is a contributing factor." Schwalbe and Rogers, Physics and Chemistry, p. 22-23.
The Gilberts themselves don't mention a fluorescence peak shift for the clear areas, but do mention that the "variation in spectral reflectance from a particular clear area to the mean clear ... was generally between ±3 and ±7% across the entire spectrum"; they only mention a peak shift in combination with fluorescence reduction for the body image and scorch areas, and explain it as follows: "the main effect of these stains seems to be the quenching of the fluorescence of the underlying cloth. In addition these stains seem to exhibit a low level of fluorescence of their own in the 600-700-nm region." Gilbert and Gilbert, Ultraviolet-visible reflectance, p. 1935. Schwalbe and Rogers commented on the background fluorescence: "Although the data suggested low-level fluorescence signals in the 600-700 nm region, the observation can be accepted only tentatively because the signals were of approximately the same magnitude as the stated maximum probable data variance." (Schwalbe and Rogers, Physics and Chemistry, p. 22)
[153] Miller and Pellicori, Ultraviolet Fluorescence, p. 80
[154] Adler, The Nature of, p. 4 (The orphaned manuscript, p. 106), referring to Mottin, Actes du III Symp. Sci. Inter. Nice, CIELT, Paris (1997).
[155] "Pectinase, and also the cellulase (but much more slowly than the pectinase) showed positive action against the non-image and radiocarbon fibers and did nothing with the image fibers in the same time period. … It would appear that Mottin's hypothesis is correct, pectic substances are present, but the matter should still be confirmed by spectral analysis." Adler, The Nature of, p. 4-5
[156] "Histology of Plant Extracellular Matrix" ascribes no fluorescence to pectin, but to lignin only (a light blue fluorescence)
http://www.cas.muohio.edu/~meicenrd/ANATOMY/Ch4_Histology/lab4.html; and for a study of "Interaction of various pectin formulations with porcine colonic tissues" pectins had to be made fluorescent artificially ("Fluorescence-labeled pectins were prepared by the conjugation of fluoresceinamine to the molecules of P-25, P-94, and P-N by Belder's method [17]." LinShu Liu e.a., p. 5908), in order to be able to observe the pectins' behaviour in the colonic tissues http://ddr.nal.usda.gov/bitstream/10113/37497/1/IND44306122.pdf ; fluorescence of lignin: "The cell walls of kenaf phoem fibers are composed of cellulose and noncellulosic substances such as hemicelluloses, pectins, and lignins [10 ... . Lignin in the fiber cells is readily detected with ultraviolet light since the aromatic ring fluoresces blue [13], and is predominantly found in secondary cell walls that begin to form after cell expansion has ceased." B.G. Aire, K. Stevens. et al, Viscoelastic Properties of Kenaf Bast Fiber in Relation to Stem Age, Textile Research Journal, Vol 79(11): 973–980, http://www.lane-ag.org/pubs/kenaf/231386-WEBBER.pdf , p. 974
[157] Pellicori, Spectral Properties, 1917, fig. 5
[158] Heller and Adler reported that a 300-year old Spanish linen cloth washed with an alkaline Saponaria extract "Resembles Shroud pale yellow fibrils" and shows a "pale yellow-green fluorescence under short wave UV" (Heller and Adler, A Chemical…, 1981, TOM 38, 51). Saponaria's flavonoid saponarin is yellow in alkaline media (pH 7.9), but is colorless in slightly acidic media (pH 5.6) (http://en.wikipedia.org/wiki/Saponarin).
[159] Fanti and Schwortz et al., Evidences for testing, Fact B58; Rogers, A Chemist's Perspective, p. 39 and 61

[160] Slide "Sticky Tape Samples from Shroud Area" shows photomicrographs of a yellow and white twisted flat fiber (dyed cotton?); photo upper left = white light; photo lower right = UV fluorescence (Villarreal, video of presentation Analytical Results, at ca. 30:57)
[161] http://en.wikipedia.org/wiki/Alizarin and http://en.wikipedia.org/wiki/Purpurin_(dye)
[162] Also the alizarin and purpurin probably were transformed by the image formation process.
[163] "Scorches – The visually dark brown burns fluoresce brownish-red. The color reddens as the scorch density decreases. Comparable to pyrolysis products, produced under limited oxygen combustion, such as furfurals." Miller and Pellicori, Ultraviolet Fluorescence Photograpy, p. 75; "Vern Miller's experiment at the academy with burning linen in a limited-oxygen atmosphere had produced a furfural-type material, which fluoresced in the ultraviolet. This jibed with the ultraviolet reflectance spectra of the Shroud." Heller, Report on, p. 175; "and the characteristic reddish orange fluorescence in the slight scorches" Heimburger, A detailed critical, p. 7-8.
[164] "The medullas (tubular voids in the centers of linen fibers) of image fibers do not show any coloration or charring (figure 6). The medullas are usually clean and colorless. Fibers that were scorched during a fire in AD 1532 show some scorching in the medullas." Rogers and Arnoldi, Scientific Method, p. 8-9; "no fluorescence emission of the image (brown) and of the blood stains (dark brown to black spots) and the characteristic reddish orange fluorescence in the slight scorches" Heimburger, A detailed critical, p. 7-8; "the color difference is obvious to the eye and in the fluorescence photography." Pellicori, Spectral properties, p. 1919.
[165] Schwalbe and Rogers, Physics and Chemistry, p. 22-23
[166] http://www.oldandinteresting.com/antique-irons-smoothers-mangles.aspx;
[167] http://www.huntsearch.gla.ac.uk/cgi-bin/foxweb/huntsearch/DetailedResults.fwx?collection=archaeology&SearchTerm=B.1914.861&reqMethod=Link
[168] http://www.wegwijslezer.nl/php/vreemd.php?selpage=55#reaction951 : "bollen uit de 8e en 9e eeuw"
[169] Fanti et al, Evidences for testing, fact B14
[170] http://www.biblegateway.com/passage/?search=Lu%2023:11&version=WHNU;HCSB;LEB;WYC;NCV
[171] Rogers, A Chemist's, p. 40
[172] Adler, Selzer and DeBlase, Further Spectroscopic Investigations, The orphaned manuscript, p. 94
[175] 13 = Adler, Updating Recent Studies, p. 225. 14 = Antonacci, The Resurrection of , p. 168 and 304; Antonacci and Heimburger, Private Internet Debate, p. 5-6
[176] "This is confirmed by the photos of the Shroud in the visible under pure UV illumination(14). They show yellow-greenish background fluorescence, no fluorescence emission of the image (brown) and of the blood stains (dark brown to black spots) and the characteristic reddish orange fluorescence in the slight scorches. (14)(= "V.D.Miller and S.F.Pellicori, J.Biol.Photograph.Assoc., 49 (1981) 71)." Heimburger, A detailed critical, p. 7-8; "Most organic colors are much less stable than cellulose (linen) and the normal inorganic pigments. Experiments in 1978 showed that scorch lines in impurities precede the scorches in pure linen." Rogers, Frequently Asked Questions, p. 12
[177] Adler had received thee radiocarbon threads: a warp thread from the outer edge of the sample, one from the inner edge, and a weft thread from the middle (Adler, Further Spectroscopic Investigations, p. 94). From each thread (which may have consisted of about 188 fibers in cross section, cf. the F15001 thread) he took five fibers: one from each end, one from the middle, one from the inside, and one at random (Adler http://shrouduniversity.com/podcasts/aladler.mp3 at ca. 6:46). Of each fiber he made a FTIR spectrum and found a great deal of variability between even the 5 spectra from a single thread. This can be explained: at fiber level there was much variability, because a fiber from a single RC thread can be either: - cotton or linen, - with a very thick, or very thin, or no coating, - scorched or unscorched, - with or without dirt deposit: because a fiber can be either from the inside of the thread, from the outside of the thread, from the top of the weave, or from the intersections of the weave. This may vary even along the length of a single fiber." The FTIR data for the radiocarbon sample … shows physical characteristics of both the waterstain and scorch regions of the cloth" (Adler, Further Spectroscopic Investigations, p. 98). The FTIR scorch characteristics of the superficial fiber samples from the main Shroud would have resulted from the scorched coating, from the scorched primary cell wall of hemicellulose and lignin, and perhaps from scorched cellulose as the medullas were charred. But merely the physical (scorch) characteristics of the thick coating in the RC FTIR data may have been enough to categorise the RC sample data as those of a scorched sample. The hemicellulose of the PCW of the FTIR fiber samples may incidentally not have been scorched because they were just too far away from the surface of the thread.
[178] http://en.wikipedia.org/wiki/Pectin
[179] "At the Nice conference, Mottin suggested … the presence of pectic substances not removed by primitive retting methods (45 Mottin, "Actes du III Symp. Sci. Inter" CIELT, Paris (1997)). As even modern linens may contain of the order of 2% of such materials (46 Peters, "Textile Chemistry", Elsevier, Amsterdam (1967).) …" Adler, The Nature of, p.4-5 (The orphaned manuscript, p. 106)
[180] Adler, The Nature of, p.4-5 (The orphaned manuscript, p. 106-107)
[181] "Pectinase, and also the cellulase (but much more slowly than the pectinase) showed positive action against the non-image and radiocarbon fibers and did nothing with the image fibers in the same time period. … It would appear that Mottin's hypothesis is correct, pectic substances are present, but the matter should still be confirmed by spectral analysis." Adler, The Nature of, p.4-5

Verwijderd: [173] http://en.wikipedia.org/wiki/Rose_madder ¶
[174] Rogers and Arnoldi, Scientific Method, p. 20¶

[182] Madder root was dried, crushed, and cooked in acidified water to extract the dye, and possibly fermented to hydrolyze the dye (http://footguards.tripod.com/06ARTICLES/ART33_madder.htm); Some say the dye was extracted "By drying, fermenting or a treatment with acids" (http://en.wikipedia.org/wiki/Madder); also pectins are extracted from plant material by cooking in acidified water (http://www.cybercolloids.net/library/pectinscience/pectin-basics-sources-and-extraction). After any fermentation of the madder some of its pectins would have survived; also after flax stems are fermented (primitively or modern) to remove the pectins, some pectins survive: "even modern linens may contain of the order of 2% of such materials (46 Peters, "Textile Chemistry", Elsevier, Amsterdam (1967)." Adler, The Nature of, p.4-5 (The orphaned manuscript, p. 106).
Svensson (Light microscopy) published some photomicrographs of different kinds of fibers from the Shroud and perhaps the Holland cloth. On some fibers a surface layer is seen. In one case an amorphous layer is "assumed to be debris from the middle lamella, which in flax mostly consists of pectin" (fig. 7 p. 4-5). In another case one doubts if an amorphous layer is pectin and suggests glue from a sticky-tape (fig. 32 p. 15). And in a third case – in which phase contrast microscopy is used which doesn't differentiate between amorphous or birefringent, but shows the surface layer is "a snake/cobblestone-like layer" – one "has sometimes seen approximately similar layers estimated to be pectin. But in this case it is impossible to rule out traces of biologic activity (fungi and/or bacteria)." (fig. 41 p. 19-20). Note that perhaps not all superficial fibers of a thread were coated with starch paste, but all superficial fibers would have been in contact with a last madder dye wash.
[183] Tribbe, Portrait of Jesus?, p. 23.
[184] Heimburger, A detailed critical, p. 5
[185] Schwalbe and Rogers, Physics and Chemistry, p. 17
[186] Rogers and Arnoldi, Scientific Method, p. 18-20
[187] "Mordant dyes require a mordant, which improves the fastness of the dye against water, light and perspiration. The choice of mordant is very important as different mordants can change the final color significantly. Most natural dyes are mordant dyes and there is therefore a large literature base describing dyeing techniques." http://en.wikipedia.org/wiki/Dye
[188] Rogers, Studies on, p. 191-192; [7] = Adler, Selzer and DeBlase
[189] Brown, Microscopical Investigation, p. 4
[190] Villarreal, Video of presentation, at 14:24 and 34:05-24
[191] "McCrone had also mentioned that he had seen "… wood charcoal and madder rose." … We examined every particle type we could find and tested it chemically, and could not corroborate any of his observations." Heller, Report on, p. 189-190 and 196
[192] Adler, The Shroud fabric, The orphaned manuscript, p. 119
[193] Ford, The Shroud of Turin's, p. 10, refers to McCrone and Skirius, Light Microscopical Study.
[194] "In Table 1 (below), it can be seen that the radiocarbon fibers, although they are from a waterstain area, are "saltier" than the waterstain image fibers from the rest of the cloth. Since the edges of the waterstains on the body of the cloth are unbounded permitting free diffusion, this implies that missing panels were already missing at the time of the 1532 fire, as such a bounded edge would concentrate diffusing dissolved salts at such an edge. Therefore, we conclude that the creation of the side strip itself also predates the time of the repairs following the 1532 fire." Adler and Whanger, Concerning the Side Strip
[195] On aragonite on the sole, nose, and left knee of the crucified man: Fanti and Schwortz, Evidences for, Fact A79; On travertine aragonite near the Damascus Gate: http://www.factsplusfacts.com/travertine.htm ; On travertine aragonite in Jerusalem tombs: Kohlbeck and Nitowski, New Evidence
[196] http://www.ehow.com/facts_6077753_ph-sugar-solution_.html
[197] Madder root was dried, crushed, and cooked in acidified water to extract the dye and possibly fermented to hydrolyze the dye (http://footguards.tripod.com/06ARTICLES/ART33_madder.htm); Some say the dye was extracted "By drying, fermenting or a treatment with acids" (http://en.wikipedia.org/wiki/Madder); also pectins are extracted from plant material by cooking in acidified water (http://www.cybercolloids.net/library/pectinscience/pectin-basics-sources-and-extraction).
[198] cf. Starch 1500 Partially Pregelatinized Maize Starch
[199] Rogers and Arnoldi, Scientific Method, p. 17
[200] Rogers and Arnoldi, Scientific Method, p. 17-20
[201] Rogers, Studies on, p. 192
[202] Rogers and Arnoldi, Scientific Method, p. 20
[203] Rogers and Arnoldi, Scientific Method, p. 20, fig. 16
[204] Rogers and Arnoldi, Scientific Method, p. 21
[205] Rogers and Arnoldi, Scientific Method, p. 20
[206] Rogers and Arnoldi, Scientific Method, p. 20
[207] Rogers, Studies on, p. 192
[208] http://www.ehow.com/about_5118056_lugols-iodine.html ; http://www.ehow.com/facts_6953722_lugol-solution_.html
[209] http://en.wikipedia.org/wiki/Tincture_of_iodine and http://wiki.answers.com/Q/What_color_does_distilled_water_turn_when_iodine_is_added
[210] "Starch Test: Add Iodine-KI reagent to a solution or directly on a potato or other materials such as bread, crackers, or flour. A blue-black color results if starch is present. If starch amylose is not present, then the color will stay orange or yellow. Starch amylopectin does not give the color, nor does cellulose, nor do disaccharides such as sucrose in sugar." http://www.elmhurst.edu/~chm/vchembook/548starchiodine.html
[211] As starch is more easily pyrolyzed in acidic environment than without acid (http://www.livestrong.com/article/277170-uses-of-hydrochloric-acid-in-foods/ and http://en.wikipedia.org/wiki/Pyrodextrin), and pyrodextrins are cold water soluble

(http://www.creagan.net/fireworks/dextrin.html), a 6N HCl solution (acidic) would also hydrolyze/dissolve some of the smallest pyrodextrins.of starch gum (the coating "dissolves at both lower and higher pH" than 8.0 (Rogers, Studies on, p. 192)). The smallest reducing pyrodextrins are (almost) similar to ordinary sugars, that dissolve both in vinegar (acidic) and in soapy water (basic).

[212] Villarreal, Schwortz, and Benford, Analytical Results On

[213] http://www.ncbi.nlm.nih.gov/pubmed/19804806

[214] Villarreal, video of the presentation, at ca. 24:35-25:38

[215] Alizarin has two OH-groups on every six C=C double bonds, purpurin has three OH-groups on every six C=C double bonds, but cellulose has three OH-groups on every three C=C double bonds.

[216] http://en.wikipedia.org/wiki/Starch and http://en.wikipedia.org/wiki/Retrogradation_(starch)

[217] http://en.wikipedia.org/wiki/Starch

[218] http://en.wikipedia.org/wiki/Dextrin

[219] http://www.creagan.net/fireworks/dextrin.html

[220] http://sehrgut.co.uk/sca/ink.php

[221] http://www.nicstarch.com/Html/Product_Conversion_001.htm

[222] http://encyclopedia.jrank.org/DEM_DIO/DEXTRINE_BRITISH_Gum_STARCH_Gum.html ; http://dictionary.reference.com/browse/Dextrin ; http://chestofbooks.com/crafts/metal/Builder-Mechanic/Dextrine-Or-British-Gum.html

[223] Adler, Updating Recent Studies, p. 225 (The orphaned manuscript, p. 82)

[224] Adler, Selzer and DeBlase, Further spectroscopic , The orphaned manuscript, p. 98

[225] Adler, Chemical and Physical aspects, The orphaned manuscript, p. 25

[226] 13 = Adler, Updating Recent Studies, p. 225. 14 = Antonacci, The Resurrection of , p. 168 and 304; Antonacci and Heimburger, Private Internet Debate, p. 5-6

[227] Antonacci and Heimburger, Private Internet Debate, p. 28

[228] "Human sebaceous secretions in sweat are about 28% free fatty acids. … These fatty acids are chemically reactive, and they catalyze many types of reactions." Rogers and Arnoldi, Scientific Method, p. 6; Rogers, A Chemist's perspective p. 47.

[229] Adler, Further Spectroscopic investigations, The orphaned manuscript, p. 94

[230] "Bent, crushed, or otherwise damaged fibrils show strain dichroism and will give an erroneous index." Rogers, Supportive comments, p. 3. "Cross polarized light clearly demonstrates characteristic cross striation in flax fibers. By some authors this striation has been named *growth nodes*. (8) However, striation originates from mechanical stress and humidity levels either during growth, harvesting or post harvesting processing. (9) Conse-quently, in this paper striations are denoted *dislocations* instead of kinks, kink bands, nodes or growth nodes." Svensson, Light microscopy, p. 2

[231] Adler and Heller, A Chemical investigation, The orphaned manuscript, table 2, p. 50

[232] Rogers, A Chemist's Perspective, p. 39

[233] "Hemicelluloses include xylan, glucuronoxylan, arabinoxylan, glucomannan, and xyloglucan. These polysaccharides contain many different sugar monomers. In contrast, cellulose contains only anhydrous glucose. For instance, besides glucose, sugar monomers in hemicellulose can include xylose, mannose, galactose, rhamnose, and arabinose. Hemicelluloses contain most of the D-pentose sugars, and occasionally small amounts of L-sugars as well. Xylose is always the sugar monomer present in the largest amount, but mannuronic acid and galacturonic acid also tend to be present." http://en.wikipedia.org/wiki/Hemicellulose

[234] http://en.wikipedia.org/wiki/Gum_arabic

[235] "Gum arabic, also known as acacia gum, *chaar gund*, *char goond*, or *meska*, is a natural gum made of hardened sap taken from two species of the acacia tree; *Acacia senegal* and *Acacia seyal*. .. Gum arabic, a complex mixture of polysaccharides and glycoproteins, is used primarily in the food industry as a stabilizer. … Acacia gum's mixture of saccharides and glycoproteins gives it the properties of a glue and binder which is edible by humans." http://en.wikipedia.org/wiki/Gum_arabic

[236] "There was no protein in areas other than the blood flows." Rogers, Frequently asked questions, p. 18, cf. Heimburger, A detailed critical, p. 21-22; "PMS was performed not on a single fiber but on a sample, i.e. thousands of fibers: obviously, proteins would have been detected. Heller and Adler demonstrated that fluorescamine is able to detect nano to picograms of proteins on old linen. They tested many image fibers from the different samples: it is highly doubtful that they would not be able to find proteins on at least some of the fibers." (Heimburger, A detailed critical, p. 27); "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)." (Fanti and Schwortz, Evidences for, Fact B10); "The proteins found by McCrone were evidenced with reagents like the black of starch that intensely colours also the pure cellulose[43 = Heller and Adler, Blood on the Shroud; Heller and Adler, A chemical investigation]." Fanti and Marinelli, Results of, #47, note 23, p. 10

[237] "In order to improve the specificity of these observations and to further check some other desired points, it was decided to resort as in the original chemical study (24) to enzymes. For example, lysozyme, trypsin, and carboxypeptidase were used to definitively resolve where proteins were or were not on what sticky tape samples (24). … Sticky tape non-image, image, and serum coated fibers were extracted from the tapes, cleaned, and characterized as in previous studies (4,24,44) and tested along with a number of fibers from the radiocarbon threads employed in the FTIR studies (4,44). The protease was only active against the serum coated fibers" ("4) Adler, ACS Symp. Series, 625, 223 (1996). 24)Heller and Adler, Can Soc. Forens. Sci. J.,14, 81 (1981). 44)Adler, Selzer, and DeBlase in ref.21 and also ref.22.; 21)"III Congresso Inter. Di

Studi Sulla Sindone" Torino, in press. 22)"Dallas Conf. on the Shroud", in press."), Adler, The Nature of, p. 4; also the FTIR spectra of radiocarbon fibers were negative for proteins (no amide groups detectable) (Adler, Presentation in Dallas in 1998, Further Spectroscopic…, http://shrouduniversity.com/podcasts/aladler.mp3 at 13:28)

[238] Van Haelst, The Red Stains; the "pre-dating 1192 area" is the poker holes area.

[239] "The hypothesis that these holes were burned through with a hot poker is probably incorrrect. Close inspection of the peripheral areas reveals a foreign material there, resembling pitch. The radiographs also show high density structures that supports this observation. This earlier damage may have resulted from burning pitch that perhaps fell onto the Shroud from a torch." Schwalbe and Rogers, Physics and Chemistry, p. 47, note 7; cf. Bonnet-Eymard, The Physics and Chemistry.

[240] Heller and Adler, A Chemical Investigation, The orphaned manuscript, p. 43 and Table 2, p. 50

[241] Rogers, A Chemist's Perspective, p. 45-46

[242] Schwortz, Mapping of Research

[243] Rogers and Arnoldi, Scientific Method, p. 17

[244] Rogers and Arnoldi, Scientific Method, p. 27

[245] Rogers, Frequently asked questions, p. 11

[246] Rogers, A Chemist's Perspective, p. 92.

[247] Rogers, A Chemist's perspective, p. 67; "Figure IX-3: Cotton and linen fibers from a warp thread of the radiocarbon sample, 800X in 1.345-index oil." Rogers, A Chemist's perspective, p. 67

[248] "The two indices of cotton are close to that of the adhesive. Birefringence is first-order white. The index of linen across the fiber is appreciably lower than that of the adhesive." Rogers and Arnoldi, Scientific Method, p.14

"The index of refraction of a normal linen fiber parallel to its length is nearly identical to that of the adhesive on the sampling tapes (it nearly disappears). That index is very close to 1.515. The index across the fiber is appreciably lower than the adhesive. The indexes of refraction and crystallinity of image fibers are identical to unaffected fibers." Rogers, Frequently Asked Questions, p. 15

"The image-color coating seems to be amorphous, but I have been unable to measure its index. ... The usual immersion oil used by microscopists has an index of 1.515, because a normal microscope slide is made of crown glass with an index of 1.517 at 589 nanometers. The index of the coating on the Raes samples varies a little, but it is very close to 1.515: It can be completely invisible on a normally prepared slide. Water with an index of 1.33 can not be used as an immersion liquid to enhance contrast, because the coating swells and dissolves." Rogers and Arnoldi, Scientific Method, p. 27

[249] Rogers, Frequently asked questions, p. 26

[250] "Figure 5: "Ghost" on sample 1EB. The tape was pulled from the calf of the leg. There is no fiber in the horizontal line, proved by rotating the sample between crossed polarizers. Cellulose is birefringent. The line shows a faint-yellow image color." Rogers and Arnoldi, Scientific Method, p. 7

[251] Rogers, A Chemist's, p. 24; Heller, Report on, p. 163; Heller and Adler, A Chemical Investigation, The Orphaned Manuscript, p, 37

[252] "no fluorescence emission of the image (brown) and of the blood stains (dark brown to black spots) and the characteristic reddish orange fluorescence in the slight scorches" Heimburger, A detailed critical, p. 7-8

[253] Guerreschi and Salcito, Further Studies on

[254] Guerreschi and Salcito, Further Studies on, p. 5.

[255] Compare http://www.shroud.com/maptap2d.htm and http://www.shroud.com/maptap2v.htm with the positions of the small water stains, in a figure on Guerreschi and Salcito, Further Studies on, p. 5.

[256] Rogers A Chemist's Perspective, p. 99

[257] Fanti and Schwortz, Evidences for, Fact B58

[258] Rogers, A Chemist's Perspective, p. 61

[259] Rogers, A Chemist's Perspective, p. 39

[260] Rogers, A Chemist's Perspective, p. 40

[261] Rogers, A Chemist's Perspective, p. 39

[262] Rogers, Comments on, p. 9

[263] "Hemicelluloses include xylan, glucuronoxylan, arabinoxylan, glucomannan, and xyloglucan. These polysaccharides contain many different sugar monomers. In contrast, cellulose contains only anhydrous glucose. For instance, besides glucose, sugar monomers in hemicellulose can include xylose, mannose, galactose, rhamnose, and arabinose. Hemicelluloses contain most of the D-pentose sugars, and occasionally small amounts of L-sugars as well. Xylose is always the sugar monomer present in the largest amount, but mannuronic acid and galacturonic acid also tend to be present." http://en.wikipedia.org/wiki/Hemicellulose

[264] Rogers, Frequently Asked Questions, p. 7-8

[265] Rogers, A Chemist's Perspective, p. 39

[266] "If the image had been formed by a scorching-type, high-temperature reaction, some pyrolysis products of linen, including furfural, might still be present. The detection of pyrolysis products would have been fairly conclusive evidence for an image-formation mechanism; however, the absence of such products would prove nothing. I got no test with Bial's reagent, so I also tried Seliwanoff's test for furfural. It gives a nice, bright red color with furfural, but it gave no test with fibers from a light Shroud scorch. Furfural polymerizes over time to form a dense, dark polymer that does not give the test. Polymerization is faster when the reaction is catalyzed with some common impurities, and it can be slowed with inhibitors. I could not prove the presence of furfural on image areas; however, it was worth the effort to try. The same tests can detect pentose sugars." Rogers, A Chemist's Perspective, p. 39-40

Another explanation might be that the starch (gum) coating on the surface fiber(s) inhibited the emergence and/or detection of any furfural from the hemicellulose on and in the tested fiber(s). Starch or glucose (or dextrins) do not give a positive Seliwanoff test, because they are aldoses (http://en.wikipedia.org/wiki/Seliwanoff and http://en.wikipedia.org/wiki/Aldose)

[267] Rogers, A chemist's perspective, p. 40 (Rogers' comment here is "I suspect that the literature descriptions of the reagent are not complete.")

[268] "The instrument at MCMS is equipped with a pulsed source that has a time resolution of 100 ns, and it produces a series of mass spectra as the sample heats up. However, it was impossible to quote an accurate, absolute sample temperature when single microfibers were being analyzed, only relative sample temperatures could be compared. … Some of the samples came from areas of apparent blood flows, some from scorched areas, one ("the Zina thread") was a complete yarn segment that had been withdrawn from the heel image area, one came from a pure image area, one came from a water stain in an image area, and several were modern reproductions of ancient linen technology. ... Compared with fibers extracted from the sampling tapes, there was ample material from the Raes sample, which should be representative of the entire Raes/radiocarbon sampling area. ... Cellulose pyrolyzes to produce hydroxymethylfurfural (mass 126), which begins to deformylate in a series reaction to produce furfural (mass 96). .... Linen fibers from the main part of the shroud did not show significant product evolution until relatively high temperatures (probably about 260 ◦C), but the products contained both expected fragments (Fig. 4). … When the first pyrolysis products appeared during heating, the Raes fibers showed a signal for furfural at mass 96 (Fig. 5). There was no signal at mass 126." Rogers, Studies on, p. 192

[269] Antonacci and Heimburger, Private Internet Debate, p. 27

[270] An important characteristic of the spectrum of the first PMS products from the Raes thread is, that it has relatively early furfural release without any release of pyrolysed cellulose products, such as hydroxymethylfurfural (HMF); "furfural appears relatively early, and it disappears quickly". (Rogers, A Chemist's, p. 57, subscript to run S16S = Rogers, Pyrolysis/Mass Spectrometry, Fig. 2 ("low-temperatures pyrolysis of fibers from Raes sample #3"). In totally scorched linen the ratio in PMS would have been the opposite: the first PMS products would contain much more hydroxymethylfurfural than furfural, as a linen thread contains much more cellulose than hemicellulose. Unscorched linen would show a little bit of furfural later (mainly from 220ºC) and then (mainly from 315ºC) very much HMF (http://www.mendeley.com/research/characteristics-hemicellulose-cellulose-lignin-pyrolysis/ and pyrolysis curves of biomass in TGA http://ars.els-cdn.com/content/image/1-s2.0-S001623610600490X-gr2.jpg) (the PMS spectrum of the "first products" of (unscorched but aged) image fibers shown by Rogers has an overlap of both products, with more HMF than furfural, perhaps at ca. 320ºC; see Rogers, Pyrolysis/Mass Spectrometry, Fig. 1 ("low-temperature pyrolysis of Shroud image sample 1EB")). The Raes thread's early ratio of much more furfural than HMF can be explained by it having been scorched at a temperature above the pyrolysis threshold of hemicellulose (ca. 220ºC) and below the pyrolysis threshold of cellulose (ca. 315ºC). This concept was published first by biochemist Colin Berry in "If the Turin Shroud is just a heat scorch, then why does it not fluoresce under uv light?", http://shroudofturinwithoutallthehype.wordpress.com/2012/06/09/rogers-condensed-cellulose-pyrolysis-products-cropped/ . The temperature at the linen surface, underneath the coating, would have been lower than in other scorches, not only because the Raes thread was at the margin of a scorch area, but perhaps also because it had a much thicker coating than other areas, because it contained cotton that binds the coating more than linen and because much more handling dirt had been deposited at the corners. The heat would have dextrinized the starch coating to starch gum, and pyrolysed the hemicellulose of the primary cell wall to furfural, without pyrolyzing the cellulose and without decomposing the furfural, which means the temperature was less than the furfural decomposition threshold of 250ºC (http://en.wikipedia.org/wiki/Furfural).

[271] Rogers, Pyrolysis/Mass Spectometry, p. 2

[272] "Dr. Kohlbeck explained to me that Sue Benford contacted him and requested if he could send her his microscopic photographs of the lance wound area where Dr. Kohlbeck made his observation. (6-BF). She explained to him that she believes what Dr. Heller thought was blood is actually the gum,dye,mordant coating which Dr. Kohlbeck referred in his findings as Starch." Bracaglia, Raes Problematic Threads, part 3

[273] Rogers and Arnoldi, Scientific method, p. 20, fig. 16, vertical fiber

[274] Schwortz, Mapping of Research, Tape-samples - Ventral Image, http://www.shroud.com/maptap2v.htm

[275] Heller and Adler, A Chemical Investigation, p. 49

[276] "To obtain replicate data, some of the pyrolysis/ms analyses had to be run on single 10–15-(micrometer)-diameter fibers that were 5–6mm long." Rogers, Studies on, p. 192

[277] "These results prove that the gum coating on the Raes and radiocarbon samples is a pentosan. None can be detected on any fibers from the main part of the shroud." Rogers, Studies on, p. 192; "This proves that the sample contained some pentose-sugar units. This is unique among all of the Shroud samples: no other area showed this pentose signal." Rogers, A Chemist's Perspective, p. 54; "the Raes sample was unique. It was contaminated with some material that produced pentose pyrolysis products at relatively low temperatures." Rogers, A Chemist's Perspective, p. 56 (note that the non-polar solvent xylene does not remove polar contaminants, such as sugars). "polypentose-containing plant gums. ... The relatively easy water solubility and hydrolysis of the encrustation suggests gum Arabic."Rogers, A Chemist's Perspective, p. 72-74 and Rogers and Arnoldi, Scientific Method, p. 21.

[278] "These fibers are aligned along the fiber axis. They are held in a parallel configuration, incrusted within in a cementing matrix of 17.1% hemicellulose, 4.2% pectin, and 2.8% lignin. Present with these associated compounds, is 62.8% cellulose. The material balance is made up of residual water, soluble fats, and waxes. After retting, the fibers are released from the plant and the material amounts are 71.1% cellulose, 18.6% hemicellulose, 2.0% pectin, and 2.2% lignin [1]." Cardamone, Structural features, p. 143 and fig. 1 (b) p. 144 (online at Rogers, Frequently Asked Questions, question 16).

[279] [2] = "Flury Lemberg, M. The Shroud Fabric: Technical and Archaeological Characteristics, The Turin Shroud Past, Present, and Future, International Scientific" (the rest of the text is defective here) Cardamone, Structural features, p. 146
[280] Rogers and Arnoldi, Scientific Method, p. 16.
[281] Rogers and Schwalbe, Physics and Chemistry, p. 14
[282] Rogers, Supportive comments, p. 3-4
[283] Rogers and Arnoldi, Scientific Method, p. 16
[284] Rogers and Arnoldi ,The Shroud of Turin, p. 7
[285] Rogers, Frequently Asked Questions, question, 13
[286] Rogers, Studies on, p. 190
[287] Rogers, Studies on, p. 190
[288] Rogers, A Chemist's Perspective, p. 40-43
[289] Rogers, Pyrolysis/mass spectrometry, table on p. 2
[290] Rogers and Arnoldi, Scientific Method, p. 16
[291] Rogers, Studies on, p. 189
[292] "In 1980, I received several threads from the 1973 textile sample[17] from Professor Luigi Gonella, Department of Physics, Turin Polytechnic. I now have them numbered and identified as the "Raes threads." I archived remaining tape samples, Holland cloth samples, and Raes threads after STURP disbanded. The samples are still available for independent scientific testing of the observations reported here." Rogers and Arnoldi, Scientific Method, p. 14
[293] The preceding "we" in A Chemist's Perspective is on p. 39 "We did not have the equipment to test the fluorescence spectrum in 1977" and the ones before that are on p. 36-37, describing the activities of the STURP team in 1980 "On January 21st and 22nd, 1980, the members of STURP met at the Air Force Academy in Colorado Springs, CO. The chemical section had access to some good microscopes, and we had brought all of the critical reagents we would need to test for blood, blood serum, and different classes of colored materials."[293] Note, that in the lignin-vanillin discussion the defective sentence "We used the time until the phloroglucinol/HCl failed to detect lignin as the criterion at 40, 70, and 100ºC, not a very rigorous method;" on p. 41 seems manipulated. "All of the medieval linens we have tested gave a good test for vanillin." p. 42 clearly refers to the STURP team again. The next are a generalizing "we": "I believe that we can be confident that the cloth is quite old."; "With enough work, we could get more accurate and confirmed kinetics numbers for lignin. It would be a good thesis project for some chemistry student who is interested in the Shroud. However, under any assumptions we may make, chemistry would suggest that the cloth is older than the published radiocarbon date." p. 43. The first "we" after the lignin/vanillin discussion of p. 40-43 refers to the STURP team again: p. 44 "Several sensitive methods should be able to detect myrrh. We could not confirm Bollone's claim for either aloes or myrrh." The text still keeps the reader at Colorado Springs, in January 1980.
But the text is mixed with intersections about a later date. On p. 37 "She also excised small sections of tape with a scalpel" must be from a later date than the joint STURP session in 1980, for excising small sections with a scalpel blade was only started by Heller and Adler in Heller's own lab in Connecticut, after the end of the joint session (Heller, Report on, p. 159, on the joint session: "Joan Janney had been playing a bit with samples of blank tape controls and the adhesive. She had put a fresh piece of tape against her blouse or sweater and then pulled off the tape and plucked the individual fibers from it. She found what I had found … That thrice-damned adhesive was incredibly sticky. If one pulled a fiber off the surface with a forceps, the stickum would stretch out about a centimeter (half an inch) before it would snap in two … Trying to pull the fiber out of the goop and away from the forceps was like trying to throw flypaper away with bare hands. … It made more sense to cut out the tape and dissolve the adhesive, but Joan had worked with it her way, and we had not, so we proceeded with the technique she had used", and p. 181 says: "Back in my own labs I would use a very tiny scalpel blade to remove fibrils and would cut out the Mylar tape around each one."). So, also the "we" in "We tested Shroud fibers and fibers from Raes threads that had been coated with a 10% egg white suspension and dried" (just below on p. 37, A Chemist's) may have been from this same later date, and may be just Ray Rogers and Joan Rogers-Janney, married to Rogers after STURP disbanded. This would be consistent with Rogers' remark on p. 63 "I had archived samples from the sampling tapes, the Raes sample, and the Holland cloth and patches after STURP disbanded."
[294] Heller and Adler, A chemical investigation, The orphaned manuscript, p. 36, 43, 49
[295] Heller, Report on, p. 120, 130, 172; It was a linen from a collection of Heller's wife.
[296] Rogers, Supportive comments, p. 3
[297] Rogers 2008 remark "The fact that the gum hydrolyzed in Bial's reagent (made with con. HCl) to give a pentose test should have given us a clue in 1980 that the Raes sample was different from the main part of the Shroud. Sometimes understanding comes slowly." (A Chemist's Perspective, p. 72), probably means that the STURP team should have tested the Raes sample in 1980. But, of course, in 1980 there was no urgent reason to test the Raes sample, because the carbon dating of 1988 had not been done yet. So, Rogers' comment "Sometimes understanding comes slowly" is a needless excuse for not testing the Raes sample in 1980.
[298] As already explained in a previous note, the "we" that did the vanillin test on Raes threads may have been Ray and Joan Rogers, after the STURP team had disbanded.
[299] Antonacci commented on Rogers to the Shroud Science Group, on June 14, 2005: "If he means, as he implied, that lignin cannot be found anywhere else on the Shroud other than the Raes sample, than the scientific method would require him to tell us how many samples were tested? What were their locations? Did STURP or someone else do the testing? If so, in what references is their work contained? In which samples could lignin not be observed on growth nodes? **Did he or they test the radiocarbon sample?** How did he or they identify lignin on growth nodes? etc. etc." Antonacci in Antonacci and Heimburger, Private Internet Debate, p. 26. Later Antonacci added two pages that are an impressive analysis of

quotations, and that say: "In fact, the following quotations from Ray's above paper can even be argued against the presence of vanillin on the Raes samples or the radiocarbon location more than they can be for its presence at these locations. … No definitive conclusions or even inferences concerning the presence of vanillin on the Raes sample can be drawn from this study, especially when other quotations from the same study also state that, "no samples from any location on the shroud gave the vanillin test." Antonacci, Second Response to, p. 1-2

[300] "Figure IX-3 shows fibers from the radiocarbon sample. ... Also notice that the linen fibers have very little lignin at their growth nodes. Indeed, the growth nodes are so clean you need polarization to see them (figure IX-4). ...
Figure IX-3: Cotton and linen fibers from a warp thread of the radiocarbon sample, 800X in 1.345-index oil.
Figure IX-4: A radiocarbon-sample warp fiber between crossed polarizers, 800X in 1.345 oil. The growth nodes rotate polarized light differently than does the body of the fiber. The birefringence color depends on the angle of the fiber *versus* the angle of the polarized light." Rogers, A Chemist's Perspective, p. 66-67

[301] "The observations of bands of color agree with historical reports on the methods used to produce ancient linen. [8]They indicate a very mild bleaching technique, unlike that used after the last crusade in AD 1291.[9]" Rogers and Arnoldi, Scientific Method, p. 5

[302] "9 Cf. Lisbeth G. Thygesen; Michaela Eder; Ingo Burgert: *Dislocations in single hemp fibres – investigations into the relationship of structural distortions and tensile properties at the cell wall level*. J Mater Sci (2007) 42:558-564. Lisbeth G. Thygesen, Jørgen B. Bilde-Sørensen, Preben Hoffmeyer: *Visualisation of dislocations in hemp fibres: A comparison between scanning electron microscopy (SEM) and polarized light microscopy (PLM)*. Industrial Crops and Products 24 (2006) 181–185. Karolina Nyholm, Paul Ander, Stig Bardage and Geoffrey Daniel: *Dislocations in pulp fibres – their origin, character-istics and importance – a review*. Nordic Pulp and Paper Research Journal (2001). " Svensson, Light microscopy study, p. 2

[303] Cardamone, Structural features, p. 144, fig. 1 (b) (online at Rogers, Frequently Asked Questions, question 16)

[304] See Fig. IX-5 = photomicrograph 6 of Raes thread #5, Rogers, Supportive comments, p. 5

[305] Shown in Rogers and Arnoldi, Scientific Method p. 9, fig. 7

[306] Shown in Rogers, A Chemist's Perspective, p. 45-46, Figure VII-3

[307] "Figure IX-5: Fibers from Raes #5 mounted in 1.515 oil. Very little lignin is visible at the growth nodes." Rogers, A Chemist's Perspective, p. 68; "Figure 6 shows fibrils from Raes thread #5. They are mounted in 1.515 index-of-refraction oil ... This view shows three linen fibrils in the field of view with one cotton crossing on top of two of them. Some small lignin spots are visible on the central linen, but most of its joints are clean. The other linen fibrils are mostly clean." Rogers, Supportive comments, p. 5

[308] Antonacci, Mark Antonacci's Reply, p. 9; Also Rogers noted that many dark spots were characteristic of image fibers: "Figure V-3 shows several linen fibers that were pulled from the image at the back of the ankle. It is a completely unpolarized photograph. ... These fibers are characteristic and representative of image fibers. There are dark deposits of lignin on most of the growth nodes." Rogers, A Chemist's Perspective, p. 68.
In 2000, Antonacci published a remarkable hypothesis on image-formation in his book "The Resurrection of the Shroud". In 2002, he gave the following interesting reply to Rogers' review of this book; "The reader can plainly see that the bands of color are not only found at the thicker lignin growth joints, but are much more obvious in photos 2,3, & 5 which are photomicrographs of various body image samples taken from the Shroud. The banded appearance is largely absent from the various cotton and non-image Shroud fibrils. Rogers' photomicrographs are actually quite consistent with what protons, deuterium and alpha particles would produce. They would color the insides of the fibrils where thick material, like lignin growth joints, can be found." (Antonacci, Mark Antonacci's Reply).

[309] Rogers, A Chemist's Perspective, p. 69-70

[310] Rogers, Frequently Asked Questions, question 15

[311] Miller and Pellicori, Ultraviolet Fluorescence, p. 75, Heller, Report on, p.152

[312] Flury-Lemberg, The invisible mending, p. 4 and 5

[313] Rogers, A Chemists Perspective, p. 47

[314] Rogers and Arnoldi, Scientific Method, fig. 18 p. 22

[315] Flury-Lemberg, The invisible mending, p. 4-5 and p. 7

[316] Marino and Benford, Invisible Mending, p. 6-7

[317] Marino and Benford, Invisible Mending, p. 10

[318] Heimburger, Cotton in Raes, part 3, p. 2

[319] Heimburger, Cotton in Raes, appendix by Fanti, fig. F1, p. 1

[320] Marino and Benford, Invisible Mending, p. 11

[321] Marino and Prior, Chronological History, p. 24

[322] Rogers and Arnoldi, Scientific Method, p.14 and 17; "Figure 6 shows fibrils from Raes thread #5. ... You can see one cotton twist (lower right), but the field of view at 400X is too narrow to see any other twists. Twists are about 1.25mm apart. According to Raes, this would identify the cotton as *herbaceum*. Each major division of the reticule is 0.026 mm." Rogers, Supportive comments, p. 2 and fig. 6 on p. 5

[323] Heimburger, Cotton in Raes, part 3, p.1; Rogers declared to the Shroud Science Group: "I have found copious amounts of cotton at the core of all of the yarn segments I have dissected." Communique to the Shroud Science Group, March 5, 2004, 2:30 AM, cited in Marino and Prior, Chronological History, p.18; cf. "Cotton is not a simple surface contaminant: It occurs throughout the Raes threads." Rogers and Arnoldi, Scientific Method, p. 14

[324] Schwalbe and Rogers, Physics and Chemistry, p. 17 and p. 47, note 6

[325] Jackson Response to Antonacci's request

[326]Jackson, Response to Antonacci's request
[327] Adler, Selzer and DeBlase, Further spectroscopic Investigations, The orphaned manuscript, p. 98
[328] Adler, Selzer and DeBlase, Further spectroscopic Investigations, The orphaned manuscript, p. 94
[329] In my opinion, the multiple-curved thread numbered 5 on Rogers' photo "as received" (Heimburger, Cotton in Raes, part 3, Fig. 14, p. 2), is the multiple-curved 'splice' of Rogers' figure 17 (Scientific method, p. 21), called "Raes thread #1" in the accompanying text. The straight thread, with just one slight curve at the end, numbered 1 on Rogers' photo "as received", looks like the thread that Nitowski had in glass vial #5 (Bracaglia, Raes Probelematic Threads, part 1, photo slide #41).
[330] Rogers and Arnoldi, Scientific Method, Figure 17, p. 21
[331] Benford and Marino, Discrepancies in, p. 16
[332] Slide: "XPS High Resolution Spectra for Twisted Overlap (R1 thread) ... The two ends are chemically similar" Villarreal, video of presentation, at ca. 14:31
[333] Villarreal, video of presentation, at 19:23 "looks very much like cotton", 12:30 "both regions, region 1 ánd region 2, are cotton",and 14:24 slide "unexpected silicon", and 33:53 "Silicon all through the tread"
[334] Villarreal, video of presentation, other Raes threads at ca. 27:00 and further; citation on age-dated linen standard at 28:22; Tama4 thread at 28:35 and further.
[335] Rogers and Arnoldi, Scientific Method, p. 16-17, fig. 11
[336] Rogers and Arnoldi, Scientific Method, p. 32
[337] Heimburger, Cotton in Raes, part 3, p.7, fig. 16 (courtesy Villarreal) and text citing Villarreal's abstract
[338] Villarreal, Schwortz, and Benford, Analytical Results On
[339] Flury-Lemberg, The invisible mending, p. 4-5
[340] http://www.ncbi.nlm.nih.gov/pubmed/19804806
[341] At ca. 24:35-25:38 of the video of his presentation, Villarreal said the crust was possibly a terpene based resin "because of the hydroxyl groups: there's only a limited number in terpene, while there are many in cellulose." (Villarreal, video of presentation); Alizarin has two OH-groups on every six C=C double bonds, purpurin has three OH-groups on every six C=C double bonds, but cellulose has three OH-groups on every three C=C double bonds.
[342] Benford and Marino, Discrepancies in, p. 15
[343] Benford and Marino, Discrepancies in, p. 10
[344] See for example fig. 5, 6 and 7 of Adler, Whanger and Whanger, Excerpt from
[345] Flury-Lemberg, Die Leinwand des, Abb. 3 a "Zeichnung: Nahttyp Masada", p. 34; cf. Wilson, 'The Turin Shroud – past, present and future', p. 2
[346] http://www.sindonology.org/shroudScope/shroudScope.shtml ; Whanger and Whanger suggested "a wide, relaxed running stitch, an s-shaped stitch. Generally, on one side of the seam the needle carrying the thread was inserted under two or three threads of the body of the Shroud fabric, then skipping two or three threads, the needle was inserted under two or three threads in the tuck itself; then again skipping two or three threads, the needle was again inserted under two or three threads in the body of the Shroud; and so on for most of the entire length of the seam" (Whanger and Whanger, Excerpt from). This suggestion is contradicted by the above mentioned observation by Flury-Lemberg, Die Leinwand des, Abb. 3, p. 34
[347] http://en.wikipedia.org/wiki/Plying
[348] Benford and Marino, Evidence for the skewing, p. 4 and 11, fig. 5
[349] See fig. 6 in Benford and Marino, Evidence for the skewing.
[350] See Benford and Marino, Discrepancies in, figure on p. 15, and Benford and Marino, Evidence for the skewing, fig. 5.
[351] Benford and Marino, Discrepancies in, figure on p. 21
[352] Antonacci and Heimburger, Private Internet Debate, p. 28
[353] Benford and Marino, Discrepancies in, figure on p. 21
[354] Fanti and and Maggiolo, The double superficiality
[355] Rogers and Arnoldi, Scientific Method, p. 33
[356] "1) The diffusion hypothesis was discharged by J. Jackson et al. (JACKSON J.P., JUMPER E.J., ERCOLINE W.R., "Correlation of image intensity on the Turin Shroud with the 3-D structure of a human body shape" – Applied Optics, Vol. 23, No. 14, July 15, 1984, pp. 2244-2270) also because it is difficult to explain the superficiality of the body image; if a reactant gas goes towards a cloth, all the fibers are touched by it, not only the outer ones. To overcome this problem it was supposed that the saccharides present on the linen fibers of the Shroud, that could be responsible of the reaction with the amines coming from the dead body, were present only on the topmost fibers of the cloth because the presence of these saccharides on the fibers were only due to the exsiccation of the washing products, such as Saponaria Officinalis after the weaving of linen yarns. This hypothesis is contradicted by the first **SEM analysis** of the linen fibers coming from the Shroud: the external coating due to polysaccharides (and probably crude starch) **does not show a structure typical of an exsiccation product.** If so a uniform distribution along the cloth thickness of the saccharides must be supposed and then the superficiality of the body image is very questionable in the gas diffusion hypothesis. This study is in progress." (Fanti, Comments on gas, p. 1.)
[357] Rogers and Arnoldi, Scientific method, p. 21, fig. 17
[358] Bracaglia, Raes Problematic Threads, part 1, photo slide #42 (= 3rd photo slide on http://holyshroudguild.org/dr-nitowski-new.html)
[359] Rogers and Arnoldi, Scientific Method, p. 20, fig. 16

[360] "I could not prove the presence of pentose sugars on the Shroud, so I could not prove that the cloth had been washed with *S. officinalis*. Only the fluorescence evidence remains to suggest the use of struthium." Rogers, A Chemist's Perspective, p. 40. (Struthium is another name for Saponaria officinalis)

[361] In a word search for starch, amylum, or paste in Pliny's work Natural History, nothing referring to the manufacture of linen is found (http://www.perseus.tufts.edu/hopper/searchresults?q=starch http://www.perseus.tufts.edu/hopper/searchresults?q=amylum http://www.perseus.tufts.edu/hopper/searchresults?q=paste).

[362] http://www.nicstarch.com/Html/Product_Conversion_001.htm (2-1. Oxidized starches and 2-2. Oxidized starch esters)

[363] The homogenized slurry is right away separated into the following fractions by a three-phase decanter (tricanter): • Starch - Heavy phase • Gluten - Middle phase • Pentosanes - Light phase. THE STARCH FRACTION is the heavy phase containing the major part of A-starch. It is re-slurred and refined - much in the same way as starch of any other origin as described in "Starch Refining". THE PENTOSANE FRACTION - the light phase from the tricanter - contains various gums. It is preferably mixed with other by-products and used as a wet feed. The wet feed may be dried, mixed with bran or sold as such. THE GLUTEN FRACTION is the complex middle phase. It contains the gluten, fibres, solubles, B-starch and some A-starch. After maturing of the gluten these constituents are split into sub-fractions. ... A-STARCH REFINING Starch is refined by washing with fresh clean water. ... The refined starch milk contains an almost 100% pure starch slurred in pure water. Starch is among the most pure of all agricultural products." http://www.starch.dk/isi/starch/tm33wheat.asp

[364] "Amylum is prepared from every kind of wheat, and from winter-wheat[1] as well; but the best of all is that made from three-month wheat. The invention of it we owe to the island of Chios, and still, at the present day, the most esteemed kind comes from there; it derives its name from its being made without the help of the mill.[2] Next to the amylum made with three-month wheat, is that which is prepared from the lighter kinds of wheat. In making it, the grain is soaked in fresh water, placed in wooden vessels; care being taken to keep it covered with the liquid, which is changed no less than five times in the course of the day. If it can be changed at night as well, it is all the better for it, the object being to let it imbibe the water gradually and equally. When it is quitæ soft, but before it turns sour, it is passed through linen cloth, or else wicker-work, after which it is poured out upon a tile covered with leaven, and left to harden in the sun. Next to the amylum of Chios, that of Crete is the most esteemed, and next to that the Ægyptian. The tests of its goodness are its being light and smooth: it should be used, too, while it is fresh. Cato,[3] among our writers, has made mention of it." Pliny the Elder, Natural History, Book 18, chapter 17 http://www.perseus.tufts.edu/hopper/text?doc=Perseus:text:1999.02.0137:book=18:chapter=17&highlight=starch

[365] No pentosans: Rogers, A Chemist's Perspective, p. 40; no non-blood proteins: "The protease was only active against the serum coated fibers", Adler, The Nature of, p. 4). "The fluorescamine tests were definitely negative on all fibrils away from blood areas. ... Thus, protein is only found associated with "blood" areas" Heller and Adler, A Chemical Investigation, The orphaned manuscript, p. 40.

[366] "Dextrins are produced in two methods: (1) physical method, by heat treatment and (2) enzymolysis method, by using amylase. As a result of those treatments, raw starches change from high-molecular structure to low-molecular structure, and give varied remarkable properties in solubility, flow-viscosity, adhesive property, and film-forming property." http://www.nicstarch.com/Html/Product_Conversion_001.htm; cf. http://www.specialchem4adhesives.com/resources/articles/article.aspx?id=757#t; reaction conditions: http://www.creagan.net/fireworks/dextrin.html

[367] Pliny the Elder, Natural History, book 13, chapter 26, http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.02.0137%3Abook%3D13%3Achapter%3D26

[368] "Very little color was obtained when the same experiments were repeated with a purified, "soluble" starch or plant gum. The starch gave a bright blue color with iodine and it showed only the slightest reaction with Fehling's solution. The plant gums did not show reducing properties. The effects would have been different after hydrolysis of the materials. It became evident that image-like colors required both saccharides and amines." (Rogers and Arnoldi, Scientific Method, p. 34). The Dextrose Equivalent of "starch is close to 0, dextrins varies between 1 and 13, maltodextrins varies between 3 and 20" http://en.wikipedia.org/wiki/Dextrose_equivalent cf. http://answers.yahoo.com/question/index?qid=20090921123649AAqlRSK ; "**dextrose equivalent value (DE)** A term used to indicate the degree of hydrolysis of starch into glucose syrup. It is the percentage of the total solids that have been converted to reducing sugars: the higher the DE, the more sugars and less dextrins are present." D.A. Bender, *A Dictionary of Food and Nutrition*. 2005. *Encyclopedia.com.* 23 Feb. 2012 http://www.encyclopedia.com/doc/1O39-dextroseequivalentvalue.html)

As dextrins are produced from starch by (dry) heating to at least 120 degrees Celsius in an concentrated acidic environment, or heating to at least 150 degrees Celsius in a dilute acidic environment (http://www.creagan.net/fireworks/dextrin.html), heating starch to 100 degrees in a very dilute acidic solution would not produce small reducing dextrins. Cf. "When mixed with hydrochloric acid under heated conditions, dry, powdered starch undergoes a chemical process called pyrolysis, in which large starch molecules break down into smaller chains of glucose molecules. Manufacturers may manipulate the size of the dextrin molecules by adjusting the source of starch, the reaction conditions or the reaction time. Dextrins commonly serve as thickening agents in processed foods." http://www.livestrong.com/article/277170-uses-of-hydrochloric-acid-in-foods/

[369] http://encyclopedia.jrank.org/DEM_DIO/DEXTRINE_BRITISH_Gum_STARCH_Gum.html

[370] "When mixed with hydrochloric acid under heated conditions, dry, powdered starch undergoes a chemical process called pyrolysis, in which large starch molecules break down into smaller chains of glucose molecules. Manufacturers may manipulate the size of the dextrin molecules by adjusting the source of starch, the reaction conditions or the reaction time.

Dextrins commonly serve as thickening agents in processed foods." http://www.livestrong.com/article/277170-uses-of-hydrochloric-acid-in-foods/

[371] http://braukaiser.com/wiki/index.php?title=Carbohydrates#Reaction_with_iodine

[372] "The amylose fraction of starch occurs in double-helical A- and B-amyloses and the single-helical V-amylose. The latter contains a channel-like central cavity that is able to include molecules,"iodine's blue" being the best-known representative. " http://lib.bioinfo.pl/pmid:10200247

[373] Rogers, Comments on, p. 13-14

[374] http://en.wikipedia.org/wiki/Dextrin

[375] At least one of the two starch components (amylopectin and amylose) is water-soluble. A scientific article says: "A survey of 22 popular organic chemistry textbooks showed that only four correctly stated that of the two components of starch, amylopectin is the water-soluble, and amylose is the water-insoluble. (MLH)" Mark M. Green, et al., Which Starch Fraction is Water-Soluble, Amylose or Amylopectin?, Journal of Chemical Education, 52, 11, 729-730, Nov 1975, http://www.eric.ed.gov/ERICWebPortal/search/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=EJ128481&ERICExtSearch_SearchType_0=no&accno=EJ128481

[376] "The presence of starch, in particular amilose [sic], on the shroud was confirmed by the fact that during testing for sulfoproteins in blood areas with an iodine-azide reagent (which bubbles vigorously when sulfur is present), a reddish background was formed." (Rogers and Arnoldi, The Shroud of Turin, p. 3)

[377] "The texture of heat-gelatinized starch mixtures is variable. Some gelatinized starch mixtures have a smooth creamy texture, while others are more pastelike. Some starches form gels after cooking and cooling. These starch gels may lack stability and slowly exude water through the gel surface. A similar breakdown of the gelatinized starch occurs in some frozen foods during thawing and refreezing. Although amylose is soluble in the hot gelatinized starch mixture, it tends to become insoluble in the cooled mixture. This phenomenon is called retrogradation and it occurs when the amylose chains bind together in helical and double helical coils. Retrogradation affects the texture of the food product and it also lowers the digestibility of the product." http://www.encyclopedia.com/topic/starch.aspx

[378] "The resulting color depends on the length of the glucose chains. Shorter chains (starting at about 9 glucose molecules in unbranched chains and up to 60 glucose molecules in branches chains) give a red color [Narziss, 2005]. These dextrines are also called erythrodextrines [Kunze, 2007]. ... Figure 9 - reaction between iodine and mash liquid on chalk. (A) lots of starch and large dextrins present, (B) large dextrins (branched and unbranched) present, (C) iodine-negative mash. At this point no or very little large dextrines are present"
http://braukaiser.com/wiki/index.php?title=Carbohydrates#Reaction_with_iodine ; "Total mash saccrification (a solution of some small a-limit dextrins with maltotriose, maltose and simple sugars) causes no change in the yellow color of iodine" http://www.homebrewtalk.com/wiki/index.php/Iodine_test
Maltodextrin ("a mixture of glucose, maltose, oligosaccharides and polysaccharides") contains 3 to 17 glucose units, has a Dextrose Equivalent of 3 to 20, and does not give a color with iodine (http://oinofood.com/Maltodextrin.htm, http://en.wikipedia.org/wiki/Maltodextrin , http://www.encyclopedia.com/doc/1O39-dextroseequivalentvalue.html ; http://www.luzhou.com.sg/products_09.htm). The customs CN code nomenclature calls a glucose chain a "dextrin", when its Dextrose Equivalent is 10 or less (http://en.wikipedia.org/wiki/Maltodextrin).
Note that the online text on the Maillard reaction experiments on linen cloth – done with "dextrin solution" plus "Saponaria solution" plus "ammonia vapor" – does not specify the kind of dextrin that was used, nor the concentration of the solutions or vapor (Rogers and Arnoldi, Scientific Method, p. 34). The 2008 book says "A technical grade of dextrin was used to model crude starch. It acts like crude starch without the free sugars and highest molecular-weight fractions, and it reduces Fehling's solution (it is a "reducing" polysaccharide)." (Rogers, A Chemist's Perspective, p. 103). This remark suggests that crude starch contains reducing dextrins (i.e. small starch fragments), which is not correct. Moreover, a typical "dextrin", i.e. with a Dextrose Equivalent of less than 10 (The customs CN code nomenclature calls a glucose chain a "dextrin", when its Dextrose Equivalent is 10 or less (http://en.wikipedia.org/wiki/Maltodextrin), can hardly be called "a "reducing" polysaccharide".

[379] "Reducing saccharides have been detected on the Shroud, and Pliny the Elder discussed the use of starch in the production of linen." Rogers, A Chemist's Perspective, p.117. Note, that Pliny the Elder doesn't seem to have discussed the use of starch in the production of linen either (see above). Also the remark that soluble reducing dextrin is a starch component ("One starch component, dextrin, dissolves in water, and it shows reducing properties with Fehling's solution. It is dissolved in a washing solution, and it concentrates at an evaporating surface." Rogers and Arnoldi, Scientific Method, p. 33) is too blunt.

[380] Rogers and Arnoldi, Scientific Method, p. 4-5

[381] Fanti et al., Evidences for testing hypotheses, fact B15

[382] Heller and Adler, A Chemical Investigation, p. 37, 43, and "Table 2 Classes of sample objects tested"

[383] Rogers, Comments on, p. 13-14

[384] Rogers and Arnoldi, Scientific Method, p. 30

[385] Rogers, A Chemist's Perspective, p. 44

[386] Bracaglia, Problematic Raas Threads part 3, and Schwortz, Mapping of research http://www.shroud.com/maptap2v.htm (F = Front = Ventral)

[387] Rogers and Arnoldi, Scientific Method, p. 5

[388] Rogers and Arnoldi, Scientific Method, p. 4-5

[389] Schwalbe and Rogers, Physics and Chemistry, p. 22-23

[390] "Maillard reaction … It results from a chemical reaction between an amino acid and a reducing sugar, usually requiring heat." http://en.wikipedia.org/wiki/Maillard_reaction
[391] http://footguards.tripod.com/06ARTICLES/ART33_madder.htm
[392] http://en.wikipedia.org/wiki/Glycoside , cf. http://braukaiser.com/wiki/index.php?title=Carbohydrates#The_glycosidic_bond
[393] Berry, If the Shroud of Turin is just a heat scorch, end of post; Rogers and Arnoldi, Scientific Method, p. 7
[394] Fanti, Comments on
[395] The owner has been identified in A.A.M. van der Hoeven, The seam and missing corners, and in A.AM. van der Hoeven, John Mark, (both on www.JesusKing.info).
[396] Guerreschi and Salcito, Further studies
[397] Flury published a photograph of the seam, showing that, after the seam had been opened by removing one of the sewing threads, two cutting edges appeared, and she wrote "Sowohl die breite Stoffbahn als auch der angefügte schmale Streifen haben an einer Seite eine Webekante und an der jeweils anderen Seite eine Schittkante. Diese Schnittkanten beider Stoffabschnitte werden in der Längsnaht zusammengefügt." (Flury-Lemberg, Die Leinwand des, Abb. 3 a, p. 34 and p. 23) (translation: 'Both the broad piece of fabric and the attached narrow strip have on one side a selvedge and on the other side a cutting edge. These cutting edges of both fabric sections are joined together in the longitudinal seam.')
In a letter of September 18, 1980, from Otterbein to Sox, temporarily published on the internet by the Holy Shroud Guild in 2011, Otterbein writes that Raes cut the sample he received in 1973 into two pieces. This probably was Otterbein's misinterpretation of Caramello, who said, according to the same letter, that Raes divided the one sample into two parts. If the seam rejoined two separate pieces, only removing the seam's sewing threads would already divide the two separate pieces of cloth that had been stitched together. No cutting would have been needed. Raes himself is cited in the letter as well, and this makes it clear that two separate pieces had been sewn together: Raes said that it is not possible to state with certainty if piece 1 and 2 derive from a different manufacture. If the seam was a mere tuck, Raes could have stated with certainty that sample I and II did not derive from a different manufacture. In 1973 a patch had not been suggested yet.
[398] "2) it is a piece of the original cloth of the Shroud which for some unknown reason became detached from the original and was then reattached by the seam;. … situation 2 also seems highly unlikely in view of the detailed thread matching that would be required and the absence of any evidence of any frayed thread ends along either side of the seam image." (Adler and Whanger, Concerning the Side Strip)
[399] "The weft threads can be traced from the Shroud through the seam continuing into the side strip in near perfect alignment. The seam appears to be a simple tuck (a portion of the cloth folded over on itself) in the Shroud fabric, which is meticulously hand-sewed in place on both sides of the tuck." Whanger and Whanger, Excerpt from, p. 2; Adler and Whanger, Concerning the Side Strip
[400] "Say to the children of Israel that through all their generations they are to put on the edges of their robes an ornament of twisted threads ('tsiytsith'), and in every ornament ('tsiytsith') a blue cord ('pathiyl' = cord, twisted thread)." Nu 15,38 (Bible in Basic English). Here the expression "an ornament of twisted threads" translates just the one word 'tsiytsith', which means (literally) a shining thing, (figuratively) ornament. But in the Septuagint – the Bible translation used in the first century in Judea – at Nu 15,38, the word 'tsiytsith' is translated as kraspeda = (plural of) hem, margin. So, the commandment of Nu 15,38 can be read as a prescription to put on every robe an ornamental margin with a blue cord in it." Hoeven, The seam and missing, p. 2
[401] Fanti, Schwortz et al., Evidences for testing, Facts A72 and A78
[402] Antonacci, Mark Antonacci's Reply, p. 4
[403] Di Lazzaro and Murra et al., Sub-micrometer coloration depth
[404] Fanti and Lattarulo, and Scheuermann, Body Image Formation; Fanti and Bottella et al., Microscopic and Macroscopic; Fanti, Hypotheses Regarding
[405] http://blogs.telegraph.co.uk/news/tomchiversscience/100126480/the-shroud-of-turin-forgery-or-divine-a-scientist-writes/