Supportive comments on the Benford-Marino '16th century repairs' hypothesis

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Ray Rogers seen examining the Shroud in close-up during the 1978 STURP scientific examination

Sue Benford and Joseph Marino have proposed an hypothesis that the sample removed from the Shroud for the 1988 ^{14}C age determination was not representative of the main part of the cloth. Their main evidence is that a photograph of the Oxford sample looks like an "invisible patch" (reweaving) and the ages determined are a function of the specific position of the sample along the strip of cloth that was cut from the Shroud. Given a few thread and fibril samples that remain from the 1978 STURP study, this is a testable hypothesis.

The attachments are named for the film roll, the exposure number, and the sample. The tape samples are identified according to our Turin mapping designations. Descriptions follow.

For colour photos of this and the further 5 figs, see last page

Fig. 1: Raes thread no. 14, dry at 400x magnification

Fig. 1 shows a frosted cotton fibril that has popped out of the thread. The thread is an anomalous tightly- twisted, stained-appearing thread. The flat, tape-like fibril is cotton, as shown by the absence of clear growth rings and part of one "reversal" or twist. There is a significant amount of cotton in the thread.

Fig 2. is an image fibril shown at 400X. The tape was made at the right foot of the image. It is a completely unpolarized photograph. It was taken with the birefringence of the tape at extinction; i.e., there is no dichroism color. Dark deposits of lignin can be seen at nearly all of the growth rings. Both fibrils show image color, but the tape background is slightly yellow, diminishing the effect. These are characteristic and representative of image fibrils. Absolutely no cotton could be found on this slide. The small dark spots where the long fibril crosses the reticule are what appear to be a blood flecks. The particles are amorphous and flat

Fig 2. Shroud tape sample 1HB at 400x magnification

The sample shown in Fig. 3 was taken from the middle finger of the right hand of the image. Again the tape color interferes, but the fibril is distinctly yellow. Dense lignin can be seen on all joints; however, some fibrils on this tape are nearly or totally clear of lignin. That fact is important, and it will be discussed in more detail. Absolutely no cotton could be found in this sample.

Fig 3. Shroud tape 3AF at 400x magnification

The tape shown in fig 4 was taken from the inside the Holland cloth backing. It is shown with the birefringent tape at extinction so that the fibrils show under crossed polarizers. One large cotton fibril crosses the view, and it is obvious that much less lignin is left at the linen growth rings. Many rings show absolutely no lignin. This is representative of the Holland cloth and normal Medieval linen-bleaching technology.

Fig 4: Tape sample 1FH at x400 magnification

The tape shown in Fig. 5 was taken from the ankle image in what was presumed to be a "noncontact" location, and assumption that is open to doubt. Most growth rings are dark with lignin. A few are not. Quantitative observations of lignin make it possible to distinguish Shroud samples from the Raes samples or the Holland cloth samples, which are known to be of medieval age and technology. A statistically significant sample is required to make the identification.

Fig 5: Tape sample 1EB at x40-0 magnification

It should be recognized that not all Shroud locations show lignin to the same extent. This is not surprising, because bands of thread in both the warp and weft are observed to have slightly different densities of colour. This fact supports the hypothesis that the Shroud was woven from linen made by the ancient technology described by Pliny the Elder. Pliny described thread made on a hand spindle whorl that was bleached in separate batches before being used in the weaving operation. Such technology leaves different amounts of lignin and some other structural materials (e.g., hemicellulose).

Figure 6 shows fibrils from Raes thread #5. They are mounted in 1.515 index-of-refraction oil for a clearer view and to enable more positive differentiation between cotton and linen. Cotton has an index parallel to the length of the fibril that is slightly above $n_D = 1.515$ and an index across the fibril that is almost equal to 1.515. Linen has an index parallel to the length that is

appreciably above 1.515 and an index across the fibril that is close to 1.515, making it possible to identify both kinds of fibrils in one index 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. 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.

Fig 6: Raes thread number 5 in 1.415 oil at x400 magnification

Small fragments of cotton and linen can also be detected with fair accuracy from their relative indices of refraction compared with the index of the tape's adhesive. The two indices of cotton are close to that of the adhesive, but the index parallel to the length is slightly higher. The index of the linen parallel to the length is appreciably higher than that of the adhesive, and it is appreciably higher than the index across the fibril. Bent, crushed, or otherwise damaged fibrils show strain dichroism and will give an erroneous index.

Observations from the samples, as indicated in the figures, suggests that there is a significant difference between the linen of the main part of the Shroud and Medieval linen. Such observations are, however, subjective, and the samples need to be compared quantitatively.

A sample of modern "Roman-style" linen (as described by Pliny the Elder) was laboriously prepared by Kate Edgerton. She grew the flax in her garden, water retted it, broke it to remove adhering sheath fragments, combed it, spun it by hand, and bleached it in water. She protected the warp with starch and wove a cloth sample. After weaving, she washed the cloth in *Saponaria officinalis*, which grows wild in Connecticut. I used fibrils from her cloth to compare with the other samples.

I also used a sample of modern, commercial linen, which fluoresces under UV illumination as a result of "fabric brighteners" for comparison.

SAMPLE	**% RINGS WITH LIGNIN**	**% RINGS WITH HEAVY**
Modern Commercial	55 total, very light	None
Repeat Commercial	57 total, very light	14 light
Edgerton "Primitive"	86 total	36
Raes Thread #5	40 total, light	None
1FH Holland cloth	60 total, fight	5 moderate
Repeat Holland cloth	73 total	7 moderate
1HB, Rt. Foot, dorsal	54 total	15 moderate
Repeat 1HB	40 total, very light	None
3AF, Middle Finger	7 light	None
Repeat 3AF	80 total, light	7 moderate
Repeat 3AF	All clean	None
1EB Ankle, dorsal	All show lignin, most light	17 moderate
1IB Scorch control	39 total	11 moderate
6AF, Side wound	40 (small sample)	

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.

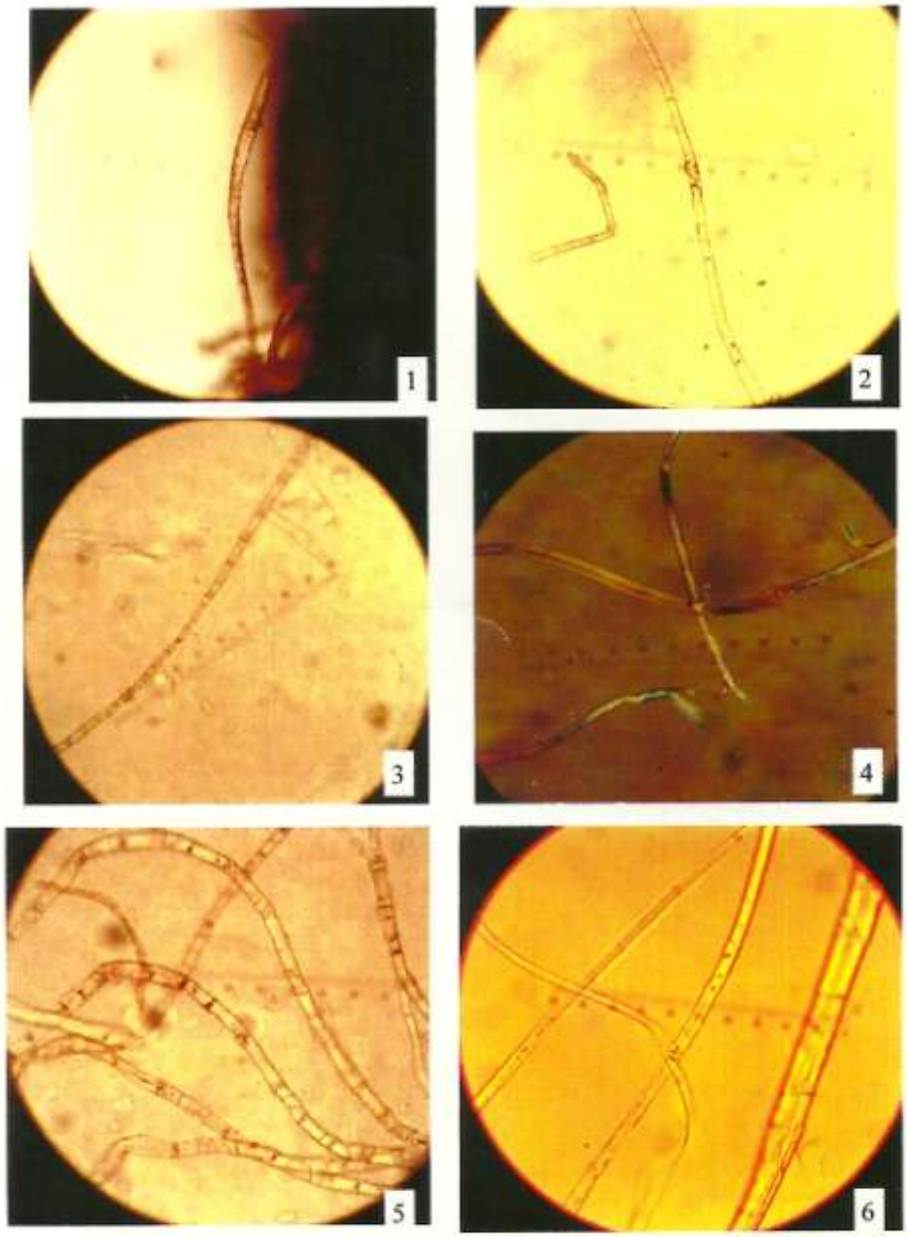
Contrast-enhanced photographs of the Shroud show specific, discrete bands of thread with different color densities. Both warp and weft threads show this property. Some areas show darker warp threads and some show darker weft threads. In some places bands of darker color cross: In other places bands of lighter color cross. The effect is somewhat like a plaid.

Linen is bleached to remove the lignin in an attempt to render it pure white. The more quantitative the bleaching process the whiter the product. The bands of different color on the Shroud are the result of different amounts of lignin left from the bleaching process. The tape samples reflect this variation as an observed difference among quantitative measurements of lignin on the fibrils.

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. The samples used for the "dating" of 1988 were cut from immediately above the Raes sample. It is very unfortunate that the ^{14}C samples were not better characterized, because the evidence shows that it is highly probable that the samples were not characteristic of the Shroud and were spurious.

Members of STURP petitioned the authorities who were planning the sampling effort for age determination to take the samples from under the patches that cover the worst burns from AD 1532. The charred material is sifting all over the surface of the Shroud and progressively obscuring the image. It would be of benefit in conservation to remove the most charred material. And such material is ideal for ^{14}C determinations. Carbon is resistant to degradation, and it can be thoroughly cleaned in nitric acid.

It would appear that age determinations should be repeated on the Shroud. The samples should be taken from the charred areas, and the samples should be characterized by elemental analysis and trace-element analysis.



Photomicrographs of Shroud thread and fibril samples from the collection of Dr. Ray Rogers (see article on pp.28 to 33 of this Newsletter),, here reproduced in full colour

Courtesy Dr. Ray Rogers