RADIOCARBON DATING
THE SHROUD OF TURIN
THE NATURE REPORT

Remi Van Haelst

INTRODUCTION

On February 16, 1989, the SEMI-OFFICIAL report of the radiocarbon dating of the Shroud of Turin was published in the British scientific journal NATURE. I like to thank the editor of Nature for the permission to use the ORIGINAL text in full, as published in Nature. Vol. 337 No 6208 pages 611--615, 16 February 1989. In this adapted version, only the important chapters will be used.

The first edition of this paper, published in 1989, was in fact the first SCIENTIFIC reply to the claimed "95% confidence" for the mediaeval radiocarbon dating result.

Radiocarbon experts and many other scientists considered this paper the work of one of the small group of "scientists of little standing", blinded by faith and their vested interest in the Shroud. Following Dr. S. Wilson, (Australia) I was "*clutching on straws*".

Every NEUTRAL scientist, reviewing this paper, will come to the ASTONISHING conclusion that ALL calculations and statements, presented here, are CORRECT. This should be a matter of great concern... But not for the radiocarbon experts !

Before rewriting this critical review, I have studied the Nature paper and recent papers on radiocarbon dating. Until TODAY, despite my repeated requests to all parties involved, including His Holiness the POPE of Rome, the official report has NOT been released. Not by the British Museum, not by any of the laboratories, not by Prof. Bray, and strangely, not by the Church authorities in Turin.

Following an anonymous letter, (dated 10-30-1988) and published 05-02-1989 in the religious information paper "IOTA UNUM", the Turin authorities were warned about an anti-Shroud intrigue, organised by the "Palazzo Giustiniani" and some members of "Opus Dei."

Recently, Cardinal Ballestrero said in a the interview, published September 5, 1997 in the German paper "Die Welt" the following: "*In my opinion, the Turin Shroud is AUTHENTIC. The radiocarbon measurements, dating the Shroud in the Middle Ages, would appear to have been performed without due care.*"

In another interview, published in an Italian paper on September 4, 1997 the Cardinal declared that he strongly suspects freemasonry of playing an important role in a campaign in which the church was accused to be an enemy of science, because it feared the truth and was frightened of loosing the relic from which it made money...

THE PREPARATION OF THE RADIOCARBON DATING OF THE SHROUD

After the development of radiocarbon dating, Father Otterbein, chairman of the Shroud Guild of America, and father Rinaldi were the FIRST to propose the radiocarbon dating of the Shroud. They contacted ex-king Umberto of Italy, legal owner of the Shroud, living in exile in Cascais (Portugal). Prof. Libby, the INVENTOR of radiocarbon dating, invited to advise ex-king Umberto, was AGAINST the DESTRUCTIVE radiocarbon dating of such a unique artefact. Following his opinion, because of the problematic CONTAMINATION, at least TWO rc.dating of the Shroud, requiring TWO pieces as large as an handkerchief, would damage

the linen. In time, because of the development of radiocarbon technology, only minute samples became required.

In 1978, a second proposal for dating the Shroud, by the experimental "Nuclear Track Dating Method", developed by Dr. W. McCrone, was brought forward. The McCrone proposal was rejected by Turin and Prof. Apers (Louvain-la-Neuve).

Cardinal Ballestrero declared, that the Church was NOT against the radiocarbon dating of the Shroud, and he asked the scientific community to establish a trustworthy method.

During the 1978 STURP experiments, suitable places for the removal of samples were selected. Prof. H. Gove (Univ. of Rochester), co-inventor of AMS ("Accelerator Mass Spectrometry"), requiring only minute samples, accepted this invitation. During the Shroud Symposium in Turin in 1978 Prof. Gove proposed to radiocarbon date the Shroud, with the new AMS-method. Despite the fact that STURP did support the radiocarbon dating proposals, Gove refused to co-operate with the American group in an inter-disciplinary examination of the Shroud !

A STURP commission, headed by Dr. Dingar of the University of Los Alamos (New Mexico), contacted 6 radiocarbon laboratories: AMS Oxford, Rochester, Arizona and Zurich and 2 small gas-counters: Brookshaven and Harwell. The Trustees of the British Museum authorised Dr. Tite to act as supervisor for the radiocarbon dating of the Shroud. To confirm the feasibility of dating the Shroud by these methods an inter-comparison, involving four AMS and two small-gas counter radiocarbon laboratories and the dating of THREE known-age textile sample, was co-ordinated by the British Museum in 1983.

The result of this INCOGNITO inter-comparison was communicated at the 1985 Trondheim Radiocarbon Congress and reported and discussed by Burleigh et al (British Museum) in "Radiocarbon. N° 28."

<center>*****</center>

Results of the INTER-COMPARISON test.
Statistical analysis based on the scatter.
Note : * = Possible outlier. $ = Mean with possible outlier.

Sample 1. Historic Age 3000 8 dates.

3440-+145	4100-+110	4170-+90	4230-+100	4340-+170	4350-+100	4380-+100	4517-+140
d13C-26.6	-25.5	-24.2	-27.0	*	-22.0	-24.1	-24.1

Scatter Mean : 4190   Error : 117   Age : 3155-2827 BC

§   4298   Error :   53   % Sig. Level

W & W Mean : 4210   40   Chi^2 = 38.34 > 14.07   0.3   Reject

§   4274   42   "   8.80 < 12.59   22.7   OK

Sample 2a Historical Age : 1200 AD. 5 Dates.

	80-+110	300-+100	450-+80	450-+ 90	530-+110
d13C -o/oo	-23.3	-22.0	-25.6	-26.2	-22.8

Scatter Mean : 362   Error   80   Age : 1400-1668 AD

§   432   "   28

W & W Mean   379   43   Chi^2 = 13.51 > 9.49   0.3   Reject

§   432   47   2.63 < 7.81   46.0   OK

Sample 2b : Historical Age 1000--1400 5 Dates

	460-+190	600-+100	620-+100	670-+130	1550*-+90
d13C -o/oo	*	-22.0	26.1	22.0	24.4
Scatter Mean 780	Error 78	Age : 1080-1400 AD			
§ 587	" 35				
W & W Mean 891	49	Chi^2 = 77.46 > 9.4 9	0.1	Reject	
§ 608	59	0.86 < 7.81	81.5	OK	

The errors here are only given for information, but they allow a statistical analysis, made following the method Wilson & Ward, used later for the Shroud. From this statistical analysis, one may wonder why the possible OUTLIERS, produced by the same laboratory, were NOT rejected by Burleigh, Tite and Leese. Were they afraid of hurting the reputation of a certain laboratory?

Despite of the total failure for sample 2a and the presence of TWO possible outliers, the authors of the paper published in Radiocarbon, concluded. "*This Inter-comparison was one of normal practice and has demonstrated that a coherent series of results can be obtained when several laboratories undertake BLINDFOLD measurements, although the occurrence of outliers emphasises the continuing need for the dating of unusually important or controversial samples to be undertaken by a group of laboratories.*"

*****

In 1982 a University in California experimentally radiocarbon dated a SINGLE thread, taken in SECRET from the Raes-samples that were then RETURNED to Turin.

Two measurements were made: 200 and 1000 AD. The difference was explained by the presence of starch. But these NON AUTHORISED experiments were never taken into account. (Although it is quite possible that the results were used to deceive some doubting minds in Turin...)

*****

In 1986 a meeting was held in Turin, at which a number of experts and the representatives of 7 rc. laboratories (5 AMS and 2 small gas-counters) were invited. The new, seventh laboratory was the French Gif-sur-Yvette, represented by Dr. Duplessy. During this meeting Prof. Meacham (University of Hong Kong) strongly opposed the whole project, because of the many possibilities of sample contamination. Other scientists present proposed a coherent series of examinations in co-operation with the STURP. This proposal, supported by Prof. Gonella, was rejected at the advice of the Profs. Gove and Hartbottle. Finally the protocol called for a BLIND TEST PROCEDURE and series of tests by AMS and Beta-counting laboratories, controlled by THREE parties: the British Museum (Dr. Tite), the Pontifical Academy of Sciences (Dr. Chagas) and the Metrological Institute "G. Colonetti" of Turin (Prof. Bray).

During this meeting the lobbying AMS versus Beta-counters started: a certain reluctance to co-operate with the Papal Academy, mutual mistrust among committee members, arguments between Prof. Gonella, Prof. Gove, Prof. Hall,...

*****

In May 1987 the offers from only THREE AMS laboratories - Oxford, Arizona and Zurich - were selected by the Vatican. Cardinal Ballestero, Archbishop of Turin. received this "strange" decision of the Pope, by a letter signed by Cardinal Casaroli.

The procedures for taking the samples and assessment of the results were discussed by representatives of the three chosen laboratories at a meeting at the British Museum in January 1988 and their recommendations were subsequently approved by the Archbishop of Turin.

Following a press release by the British Museum, the certification of the Shroud samples and the statistical analysis of the data would be the JOINT responsibility of Dr. Tite and Prof. Gonella. One may wonder, why Dr. Tite and Prof. Gonella did not advise to trust the assessment in BLIND of the radiocarbon dating results, in TOTAL BLIND, to NEUTRAL statisticians... Prof. Gove the "father of AMS", after been eliminated, made the almost prophetic remark: "*I fear sadly that Mike Tite has taken on a responsibility which he and the British Museum may live to regret.*" In the same letter (January 27, 1988) Prof. Gove called Prof. Gonella a scientist of little standing, a suspect because of his vested interest in the Shroud.

Strangely, Dr. Tite contacted in SECRET the French Prof. J. Evin to provide him with a "fourth" sample, historically dated about 1300, by co-incidence the assumed age of the Shroud. At first, Prof. Evin was not able to find such a linen sample. Finally, some threads, taken from the cape of Louis d'Anjou (Basilica St. Maximim. Var. France) became the "fourth" sample.

THE SAMPLE TAKING

The samples to be radiocarbon dated were taken on April 21, 1988. The operation was prepared by Prof. Riggi. Following the protocol, calling for BLIND testing, NINE identical small stainless steel containers, about 5 cm high, diameter 2 cm., were prepared.

The operation started early in the morning, at 04.30. After an endless discussion, the place to cut the sample was chosen. The Shroud was PARTLY separated from the backing cloth. Following his OWN notes, Riggi cuts off a strip of 8x1 cm.

Because of the presence of foreign material, judged to be harmful to radiocarbon dating, a piece of 1 cm² linen was removed.

The weights for the FOUR sets of THREE samples, as recorded in milligram, by Prof. Riggi :

| Shroud : | 52.0 | 52.8 | 53.7. | Nubia : | 51.9 | 57.1 | 57.9 |
| Egypt : | 56.6 | 56.6 | 58.8. | France : | 68.8 | 68.9 | 69.7 |

Lets us read "L'Osservatore Romano" (23-04-88) .

"On 21 April 1988 THREE samples were taken from the linen of the Holy Shroud to be dated by the radiocarbon method. Cardinal Ballestrero, Archbishop of Turin and Custode of the Shroud, was present by the operations and has officially certified the origin of the samples, with the co-operation of Dr. M. Tite of the British Museum and he has personally given the samples to the representatives of the laboratories, present in Turin.

The samples from the main body of the Shroud, circa 150 mg were cut from a strip of 1x7 cm. To assure dating in BLIND, each laboratory received three sealed containers with the Shroud samples and two control samples, without any specification.

All operations have been controlled by Prof. Testore (Polytechnics Turin. Italy) assisted by Mr. G. Vial of the "Musée Historique des Tissus" (Lyon, France)

All operations are video-recorded and documented by photos."

There can be no doubt about this statement, published world-wide and used later, LITERALLY, in the Nature report.

> But most of the statements published in the Vatican paper and in Nature are NOT TRUE!

After the sample taking the Shroud was examined by experts in order to take measures to assure the conservation of the linen.

The presence of fungi and parasites was attested to be larger than stated in 1973. Some places needed special attention and care. The dirtiest places were vacuum cleaned to collect debris for further survey. The red silk protection cloth was disinfected.

THE RADIOCARBON DATING VERDICT

NOTE :

The reconstruction of the operations at the laboratories and the British Museum is based on evidence UNKNOWN, when the first edition of this paper was presented, BEFORE, the International Shroud Symposium, organised by the French group CIELT, September 1990.

During that Symposium, I had the opportunity to debate with Dr. Tite Prof. Evin and Prof. Gonella. I invited all three to verify my statistical analysis.

A perfect British gentleman, Dr. Tite, being not a statistician, said he would ask the advice of Dr. M. Leese. The French radiocarbon expert Prof. Evin said that the difference between the time of Christ and the radiocarbon mediaeval age could never be explained by a negative statistical analysis.

Prof. Gonella told me, in a not so friendly way, that he was not pleased at all with the way, the operations were conducted, against his conception, by Dr. Tite and the laboratories.

Research at the THREE laboratories was also done by the French group Contre Réformation Catholique. Our findings were about the same.

The radiocarbon experts did not do their investigations seriously and they surely did not answer the questions about the representativity of the samples.

But I do not support the allegations, made by the CRC group, against eminent scientists like Dr. Hedges, Dr. Woeflfi and the Arizona team.

<div align="center">*****</div>

ARIZONA

Back from Turin, Damon and Donahue broke the seals and opened the containers in the presence of Miss Donahue, who photographed the Shroud sample. A photo, not for the files, but for the family album !

The samples were examined under a microscope. On the Shroud sample a strange RED silk thread was found, probably a part of the red protecting cloth. Strange, because the samples were microscopically examined by the Italian experts Riggi and Testore ! This fact was NOT recorded in the Arizona files.

Arizona started the dating of the Shroud samples the first week-end of May. The sample was cut in four pieces, who were weighted after chemical cleaning, by Dr. Toolin :

<div align="center">13.86, 12.39, 11.83 and 14.72. mg;.</div>

A total weight of 52.8 mg, corresponding with the weight of one of the samples, weighed in Turin by Prof. Testore. Strange, because the same weight is given at Zurich !

The linen samples were, after combustion to CO_2, converted into pure carbon. From this pure carbon a number of "targets" were prepared. Tucson refused a BBC team; but some home recordings were made. Four sessions, each of TWO measurements, were made WITH the SAME set of standards and blanks.

The first day, in the presence of among other invited guests, Prof. Gove, the AMS computer guided machine was loaded with a number of carbon targets, prepared from the first sample. The experts knew that if the Shroud was genuine the fraction of MODERN carbon, displayed on the screen should be about 0.75. It only took about 15 minutes before the result of the first run came on the screen : 0.8926 !

From that moment on, the radiocarbon experts of Arizona were convinced that the sample in the machine could only, at the most, be 1000 radiocarbon years old.

The second run gave the following result : 0.8892, equivalent to a RAW rc. age of 915 years.

The other RAW carbon fractions :

Day 2 :   0.8735 (Raw rcy 1062)   0.8864 (Raw rcy 941)

Day 3 :   0.8817 (Raw rcy 941)   0.8963 (Raw rcy 849)

Day 4 :   TWO runs gave the same result 0.8790 (Raw rcy 1066)

According to the Nature report, the -d13C correction was applied in a later stage.

Early June, Arizona forwarded the following results to the British Museum:

May 6	May 12	May 24	June 2
574-+41	753-+51	676-+59	701-+47
606-+43	632-+49	540-+57	701-+47

The mean -+ errors for Arizona, were calculated following the method developed by the Australian scientists Drs. Wilson & Ward:

Pooled Age :

$$\frac{540/57^2+574/41^2+606/43^2+632/49^2+676/59^2+701/47^2+701/47^2+753/51^2}{1/57^2 + 1/41^2 + 1/43^2 + 1/49^2 + 1/59^2 + 1/47^2 + 1/47^2 + 1/51^2} = 646.51$$

Error :

$[1/(1/57^2 + 1/41^2 + 1/43^2 + 1/49^2 + 1/59^2 + 1/47^2 + 1/47^2 + 1/51^2)]^{0.5} = 17.07$

I verified the consistency of these results by the Chi^2 test.

$(540-646.51)^2/57^2 =$	3.492	$(672-646.51)^2/59^2 =$	0.187
$(574-646.51)^2/41^2 =$	3.128	$(701-646.51)^2/47^2 =$	1.344
$(606-646.51)^2/43^2 =$	0.888	$(701-646.51)^2/47^2 =$	1.344
$(632-646.51)^2/49^2 =$	0.088	$(753-646.51)^2/51^2 =$	4.360
	7.596 +		7.235 = 14.831

The calculated test Chi^2 14.83 > 14.07, the value critical test value for (8 - 1) = 7 degrees of freedom for a 95 % confidence. Such a NEGATIVE result indicates an irregularity in sampling, cleaning or measurements. Because radiocarbon experts claim that errors in their cleaning and measurements methods are excluded, the only possibility is the NON HOMOGENEITY of the Arizona samples.

It is clear that a range of 540 -753 years is a little bit too wide for the claimed accuracy of AMS machines !

Dr. Donahue, probably not at ease with such a large age range and the IMPOSSIBILITY - to modern dates 632, 606, 574 and certainly 540 - dating the Shroud in the 15th century AD, added a note : "*We have still some cloth left and we would be prepared to undertake further measurements if questions are asked.*"

Indeed, in London one was not very happy with the Arizona results... But one did not ask Arizona to use the spare sample for a NEW test !

*****

ZURICH

Zurich made the measurements in mid June. Here all operations were conducted by Dr. Woeflfi in person. The weight of the Shroud sample was 52.8 mg, the same weight as noted in Tucson.

From this sample about 20 mgs pure carbon was prepared.

Following 14C fractions were recorded : (Estimated)

0.8755 (1100)   0.8766 (1089)   0.8811 (1046)   0.8855 (1006)   0.8855 (1002)

Zurich entered the following FIVE results, corrected for dC13 :

733-+61   722-+56   639-+45   635-+57   679-+51.

A value of -d 13C 25.1 o/oo was measured simultaneously, by the AMS. machine.

Pooled Age (Normalised for -d13c = 0.025) 676-+ 24

I verified the consistency of these results by the Chi^2 test. A test value of 2.74 < 9.49 indicates that the results for Zurich are consistent.

A black and white photo of the sample with a scale, was made. The existence of that photo remained UNKNOWN and has been NOT recorded. Under the microscope NO contamination of any kind was recorded. Here Rev. D. Sox and a British BBC TV crew were present. The programme "Threads of Evidence" was programmed BEFORE the official proclamation of the results... Sox included some "inside" information in a book, published *before* the official announcement of the results !

Following the normal procedure, the samples were re-coded, and so the technical staff of the AMS machine did not know the identity of the samples to be measured.

LONDON

In London one was aware of the problem that some of the Arizona dates were YOUNGER to the radiocarbon age 610, the equivalent for the year 1350 AD, considered the FIRST historical recorded date for the existence of the Shroud. A clever mind, probably inspired by the technical advice of a radiocarbon expert, found a solution!

All Arizona dates, measured the SAME day, with the SAME set of standards and blanks, should be considered to DEPENDENT dates.

From the legend, under table 1 (Nature) about the Oxford sample one can find the source of inspiration : "*one anomalous replicate out of SIX, for the INDEPENDENT sample O2.2b.*"

It was decided to ask Arizona to COMBINE each pair of DEPENDENT dates into FOUR INDEPENDENT dates.

Because of a tight schedule an operating problems, Oxford made its measurements from July 13 to July 21. By coincidence AFTER the results of the other laboratories were known...

Of course, we do not know if Prof. Hall, member of the board of the British Museum, was informed "by a favourable wind" about the results of the other laboratories before Oxford started its measurements. But it is clear that one cannot exclude this possibility !

To assure "blind testing", all operations were conducted by Prof. Hall alone. in the absence of Dr. Hedges. Prof. Hall broke the red seals of the containers. No witnesses allowed !

The weight of the Shroud sample was 50.0 mg. A value NOT recorded by the Italian experts!

The samples were examined under the microscope. On the Shroud sample some strange threads were found. These threads were sent to the Derby laboratory for examination and identified as "Quite old Egyptian cotton". (See the ""thanksgiving" in Nature).

A black and white photo was made. But the existence of this photo was NOT recorded.

As in Zurich, the samples were re-coded and the technical staff was NOT informed about the identity of the samples. Anyway, graphite targets do look alike...

The following estimated 14C fractions were recorded :

$$0.8655 \ (1195 \ rcy) \qquad 0.8708 \ (1145 \ rcy) \qquad 0.8723 \ (1130 \ rcy)$$

The Oxford -d13C measurements for samples 1 and 3 were made by the laboratory of Harwell. The -d13C values for the other samples 2 and 4 were estimated to be the same !

By coincidence, the -d13C value 27 o/oo for the Shroud was 2 o/oo LOWER than at the other two laboratories. This means that the date "normalised" to -d13C = 25 o/oo, will be about 40 rc. years YOUNGER than the RAW dates.

Oxford entered the following results for the Shroud :

$$795 \ \text{-+}65 \qquad 745 \ \text{-+}55 \qquad 730 \ \text{-+}45$$

Pooled Age : 750-+ 30

I verified the consistency of this results by the Chi^2 test. A test value of 0.68 < 5.99, the critical Chi^2 test value, indicates that the Oxford results are consistent

<div align="center">*****</div>

After receiving the Oxford results, Dr. M. Leese of the British Museum reviewed the results.

If one compares the results obtained by the British Museum with the results of a computer programme, one may wonder, how to explain the differences between 672-+13 (computer) and 689-+16.

Pooled Age : (Nature 689)

$$\frac{646.51/17.17^2 \ + \ 749.17/30.70^2 \ + \ 676.14/23.74^2}{1/17.17^2 \ + \ 1/30.70^2 \ + \ 1/23.74} = 672.44$$

Error : (Nature : 16)

[1/(1/17.17^2 + 1/30.70^2 + 1/23.74)]^0.5 = 12.67

Chi^2 :(Nature : 6.4)

$$(646.51 - 672.44)^2/17.17^2 = 2.281$$

$$(749.17 - 672.44)^2/30.70^2 = 6.367$$

$$(676.14 - 672.44)^2/23.74^2 = 0.042$$

$$\text{Chi}^2 \text{ test value} = 8.690$$

A Chi^2 test value of 8.69 > 5.99, the critical value for 95 % confidence and (3-1) degrees of freedom, indicates that the results are NOT consistent.

When I saw the results, as published in Nature for the first time, I was unaware of the importance of -d13C values for the Shroud :

$$(o/oo) \ \text{Arizona} : 25 \qquad \text{Zurich} \ 25.1 \qquad \text{Oxford} \ 27$$

In radiocarbon dating the ratio of the STABLE isotopes C13/C12 was considered to be a fixed value. Today, the University of Victoria (Canada) uses the DIFFERENT ratios C13/C12 to determine the origin of crude oils.

The ratio 14C/12C in the five main components of crude flax is not the same !

After correspondence with Dr. Nicholas van der Merwe (University of Harvard and Cape Town), who uses small differences in d13C in his research on ancient diets, I became aware of the importance of the apparently small difference of 2 o/oo in d13C, between Oxford and Arizona. In practice, the LOWER d13C of 27 o/oo for Oxford was convenient to REDUCE the gap between Oxford and the two other laboratories !

In general the dC13 for cellulose = -23-25 o/oo. But no one contested the -27 o/oo for Oxford.

Theoretically, the statistical analysis of any radiocarbon dating result should be conducted on the RAW 14C results NOT converted into years. (Polach 1976)

Because none of the laboratories gave any information on their RAW results, I had to recalculate an estimated value for the RAW fractions of modern 14C.

Age	% 14C	Error	Age	% 14C	Error	Age	%14C	Error
Arizona			**Oxford**			**Zurich**		
591	0.8908	0.0032	730	0.8723	0.0047	635	0.8859	0.0061
606	0.8892	0.0044	745	0.8707	0.0058	639	0.8855	0.0048
690	0.8802	0.0037	795	0.8655	0.0068	679	0.8812	0.0054
701	0.8790	0.0035				722	0.8766	0.0059
733	0.8754	0.0065						
Mean								
647	0.8848	0.0018	749	0.8703	0.0032	676	0.8815	0.0025
Chi^2 test								
	8.67 > REJECT			0.69 < 5.99 OK			2.75 < OK	

Final Mean = 672-+13 0.8813 -+ 0.00

Chi^2 = 15.36 >>> 5.99 REJECT.

In other words the too LOW dC13 for Oxford reduces the difference between the Oxford mean and the final mean by about 40 years, reducing the Chi^2 value from 15.36 to 8.56 !

To the deception of those involved, Dr. Leese found INCONSISTENCY between the results provided by the three laboratories. This has been confirmed by Dr. Tite. The British Museum did not wish to examine the reason(s) for this lack of homogeneity.

A new series of tests was excluded. Probably, one did not like to expose the reputation of one of the laboratories by asking Turin for spare samples.

According to the Nature report, the Chi^2 test results show that it is unlikely that the errors quoted by the laboratories for sample 1 fully reflect the overall scatter...

Here one forgets that the quoted errors are measured values of standards and blanks, made during the same run. It is not very logical the accept the radiocarbon results and reject the errors...

The easiest solution to find out which of the laboratories was responsible for the lack of homogeneity between the results, provided by the three laboratories, would be to carry out some rather simple tests.

Wilconson test ("Repertory of Mathematics" Agon-Elsevier. p.0 259)

This test is INDEPENDENT from the type of DISTRIBUTION of the dates. In this simple test one writes down the results for TWO laboratories, the largest value on the left. After the results of the laboratory (A) that gave the LARGEST result, one notes the number of results from the other laboratory (B).

The same procedure is repeated for all results of laboratory A. All values under the results of laboratory A are counted up and compared with the reference value :

(Number of results A x Number of results B)/2.

Example :

Test for Arizona - Zurich. Reference value (4 x 5)/2 = 10.

Test value 733 (4) 722 (4) 701 690 679 (2) 639 (2) 635 (2) 606 591 = 4 + 4 + 2 + 2 = 12.

Conclusion :

The zero hypothesis that both random samples are from the same population is confirmed.

Test for Zurich - Oxford. Reference value is (3 x 5)/2 = 7.5

795 (5) 745 (5) 733 730 (4) 722 679 639 635 = 5 + 5 + 4 = 14.

Conclusion :

The zero hypothesis that both random samples are from the same population is rejected.

Test for Arizona - Oxford. Reference value = (3 x 4)/2 = 6

795 (4) 745 (4) 730 (4) 701 690 606 591 = 4 + 4 + 4 = 12.

Conclusion :

The zero hypothesis that both random samples are from the same population is rejected.

t-test (Reference "Repertory of Mathematics" page 263)

Another test is the t-test, for the comparison of TWO means. One may wonder why Dr. Leese did not use this test.

	Arizona				Oxford			Zurich :				
	701	690	606	591	795	745	730	733	722	679	639	635
Total				2588			2270					3408
Number of dates				4			3					5
Mean				647			757					682
Sum of squares :	(701-647)^2=2916				(795-757)^2=1444			(733-682)^2 =2601				
	(690-467)^2=1849				(757-745)^2= 144			(722-682)^2 =1600				
	(647-606)^2=1681				(757-730)^2= 729			(682-679)^2= 9				
	(647-591)^2=3136							(682-639)^2 =1849				
	(682-635)^2 =2209											
Totals				9582			2317					8268

t-test =   The t-test value should be LOWER than the critical 97.5 % t-value for a TWO TAIL test and a degree of freedom (Total number of dates - 2)

Degrees of freedom and critical values for t :

Arizona - Oxford : 4 +3 - 2 = 5 t = 2.57

Arizona - Zurich : 4 + 5 - 2 = 7 t = 2.36

Oxford - Zurich : 3 + 5 - 2 = 6 t = 2.45

Arizona - Oxford.
757-647 = 110 x [[4 x 3 x (4+3-2)]^0.5] / [(4+3) x (9582+2317)]^0.5 = 2.95 > 2.57 Reject

Arizona-Zurich.
682-647 = 35 x [[(5 +4) x (5+4-2)]^0.5 / [(5 +4) x (8268 + 9582)]]^0.5 = 1.34 < 2.36 OK

Oxford - Zurich :
757 - 682 = 75 x [[4 x 3 x (4+3-2)]^0.5 / =   2.45 >< 2.45
                              [(4+3) x (8268+2317)] = 2.45 >< 2.45 Borderline.

This test shows CLEARLY that the Oxford dates are not compatible with the Arizona dates. One may assume that Dr. Leese did not wish to use this type of analysis, because it is based on the scatter of results.

But she did not use the recommended Wilson-Ward method to test for consistency, based on the method of the "MOST LIKELYHOOD".

Another possibility was to test the INDEPENDENT laboratory results against their means, with the same Chi^2 test, used for the means.

Chi^2 for each laboratory, based on table 1 (Nature).

Max Chi^2	Arizona	7.810	Oxford	5.99	Zurich	9.49
Calculated		8.671		0.598		1.871
Conclusion :		Reject		OK		OK

Following the intra laboratory Chi^2 tests, Arizona performed not adequately. Following the inter laboratory Chi^2 test, Oxford performed not adequately. But it was decided, because of the limited number of dates, not to reject any particular laboratory, but to REWORK the dates.

Dr; Donahue agreed, on August 4, to accept the "combined" dates as proposed by the British Museum. He noted in his answer, that this "combination" would not change the final Arizona mean -+ error, but cause very small errors for the INDEPENDENT dates.

The combination was made as follows :

Radiocarbon Ages	Errors
(606/41^2 + 574/45^2)/(1/41^2 + 1/45^2) = 591	[1/(1/41^2 + 1/45^2)]^0.5 = 30
(753/51^2 + 632/49^2)/(1/51^2 + 1/49^2) = 690	[1/(1/51^2 + 1/49^2)]^0.5 = 35
(676/59^2 + 540/57^2)/(1.59^2 + 1/57^2) = 606	[1/(1/59^2 + 1/57^2)]^0.5 = 41
(701/47^2 + 701/47^2)/(1/47^2 + 1/47^2) = 701	[1/(1/47^2 + 1/47^2)]^0.5 = 33

Pooled Age

$$\frac{591/30^2 + 606/41^2 + 690/35^2 + 701/33^2}{1/30^2 + 1/41^2 + 1/35^2\ 1/33^2} = 646.51$$

Error :

[1/(1/30^2 + 1/41^2 + 1/35^2 + 1/33^2)]^0.5 = 17.17

Again I verified the consistency of these FOUR results by the Chi^2 test. A NEGATIVE Chi^2 value of 8.40 > 7.81, the critical Chi^2 value for 95 % confidence and (4-1) degrees of freedom, indicates that the sample for Arizona is not homogenous. Nevertheless, these values are given as INDEPENDENT values in Table 1 of Nature. As one will see in the notes by the Nature report, Dr. Leese will explain in a very complicated way, how but NOT why he did bias the results, in order to TURN the NEGATIVE Chi^2 value of 8.55, first into a "borderline" case 6.4 and secondly, as by magic, into "95 % confidence" !

First the Arizona error 17 was ENLARGED to 31. Without any clarification...

The result of this "adaptation" was a diminution of the Chi^2 value from 8.55 to 6.4 and a SHIFT in the mean-+error from 672-+13 to 689-+16. Still a very narrow error range.

To eliminate this problem it was decided to REPLACE the date 689-+16, based on the quoted errors, by the mean 691-+31, based on the scatter between the means, based on the quoted errors.

Normally, to obtain a 95 % confidence, in fact the 97.5 value % for a TWO TAIL test, the error range on the mean-+error of 691-+31, (at 68 % confidence) is multiplied by the t factor 1.96 for 120 degrees of freedom.

Here one decided to estimate the degrees of freedom, lying between (3-1) laboratories and (12-3) dates, on the basis of an analysis of variance on the 12 individual measurements supplied by the laboratories. The result : td = 5 and the multiplying factor is 2.571. (Reference : Caulcott & Boddy. Statistics for Analytical Chemists. Chapman & Hall London)

By this "adaptation", the error range 13 x 1.96 = 25 was enlarged to 31 x 2.57 = 80 !

I was not able to obtain the reference work, but I wonder how Dr. Leese was able to convert the Wilson & Ward dates in a classical analysis of variances. But Dr. Leese did not wish to show me her calculations...

The "revised" report, with the biased assessment and the statistical analysis made by Dr. Leese, has been reviewed and approved by Prof. Bray ("Istituto G.Colonetti" Turin).

On September 28, 1980, Cardinal Ballestrero received the report, signed by Dr. Tite. On October 13, 1989, in Turin, the Cardinal announced OFFICIALLY during a press-conference: "*The calibrated calendar age range, assigned to the Shroud cloth with 95% confidence level is from 1260 to 1390 AD. More precise and detailed information on the result will be published by the laboratories and Dr. Tite in a scientific journal with a paper under elaboration. Prof. Bray of the Institute of Metrology "G.Colonnetti" confirmed the compatibility of the result.*"

One may wonder why the Church did not wait for "more precise and detailed information" to be examined by NEUTRAL scientists ?

The reason was probably that about the same time Dr. Tite, Prof. Hall and Dr. Hedges did the same announcement before the world media in London. The three man sat in triumph before a blackboard with the date 1260-1390 AD ! For a short time, the "unmasked" Shroud was hot front page news.

Astonished by this "fatal news", I started my own research, contacting the Turin authorities, the laboratories and the British Museum. I was told to wait until the publication of the report in a scientific journal. I thought that this journal would be the famous paper "RADIOCARBON." Instead, Dr. Tite preferred a publication in the more popular paper Nature.

THE NATURE REPORT

Note :

A publication in NATURE means of course that the paper has been reviewed by a "team of referees and peers". The only remark made by the referees of Nature was to change the size 1 cm x 7 cm into 10 mm x 70 mm. At first sight, doubts seem to be excluded. The paper in Nature is co-authored by 21 scientists, working at high-ranked institutions, under the co-ordination of Dr. Michael Tite (British Museum).

ABSTRACT

Very small samples from the Shroud of Turin have been dated by AMS (Accelerator Mass Spectrometry) in laboratories at Arizona, Oxford and Zurich. As controls, three linen samples whose ages had been determinate independently were also dated.

The results provide conclusive evidence that the linen of the Shroud of Turin is mediaeval.

* Note 1 :

It may be useful to compare this statement, with a pre-printed OFFICIAL radiocarbon dating report of the University of Oxford. The footnotes read :

(i)   It should be borne in mind that the measurement has been made on organic material and that this cannot be regarded as a guarantee of the article's date of manufacture.

(ii)   When the Laboratory is informed that the sample has been treated with a preservative or fungicide care is taken to remove this. It should be noted however that the undetected presence of such contaminants may effect a radiocarbon result.

(iii)   This result is given in good faith; however the Laboratory takes no responsibility for financial loss incurred through an erroneous report being given. These notes do reflect exactly the opinion on radiocarbon dating results of many historians and archaeologists.

For the complete text see Nature. Only important paragraphs are discussed.

Line : 11040

To confirm the feasibility of dating the Shroud by these methods an intercomparison, involving four AMS and two small-gas counter radiocarbon laboratories and the dating of THREE known-age textile sample, was co-ordinated by the British Museum in 1983. The results of this intercomparison are reported and discussed by Burleigh et al. ("Radiocarbon. Nr. 28.")

* Note 2 :

I may seem unbelievable but this is NOT correct !

The Burleigh-report stated : "The 6 laboratories received TWO samples." Silently, sample 2 became 2a and 2b... (See above).

REMOVAL OF SAMPLES FROM THE SHROUD. Line 11050.

The Shroud was separated from the backing cloth along the bottom-left hand corner and a strip (± 10x70 mm) was cut just above the place where a sample was previously removed in 1973. The strip came from a single site of the main body of the Shroud, away from patches and or charred areas. Three samples, each -+ 50 mg were prepared from that strip.

Note 3 :

I have studied the video of the entire operation. There is no doubt that Prof. Riggi did not cut a strip of 8 x 1 cm, but a strip of -+ 8.1 x 2.9 cm from the main body of the Shroud. Weights and sizes are in contradiction with the values given in Nature ! The sample had the form of a rectangular TRAPEZIUM, missing in one of the corners the "Raes sample", a kind of IRREGULAR triangle 6.1x1 cm. Surface : 3.05 cm²

Based on the official specific weight of 23 mg/cm one can estimate the SURFACE of the trapezium : 497/23 = 21.61 cm²

To obtain a rectangle we have to add the void corner : 21.61 + 3.05 = 24.66 cm².

Compare with L x W = 8.1 x 2.6 = 21.06 cm². From this sample was cut a strip of …? Until the publication of the Riggi-Testore reports in Paris (September 1989), the size [1x7 cm] was reported by "L'Osservatore Romano", Prof. Riggi, Prof. Evin, Dr. Tite of the British Museum and Dr. Woeflfi.

To avoid any confusion I will quote the GERMAN text from the E.H.T Zurich Yearbook 1988 (Page 48) : *"..ein etwa 1 cm. breiter und 7 cm langer Streifen wurden in drei je etwa 50 mg schwere Proben unterteilt..."*

Translation : "...a strip, about 1 cm wide and 7 cm long was divided into three samples weighing about 50 mg."

But on the same page a photo of the sample was published, with the GERMAN legend:

Masse des Turniner Grabtuch (Zurich) 1.4 x 1.8 cm. Abbildung mit mm Massstab. Dimensions of the Shroud (Zurich) 1.4 x 1.8 cm. Representation with a mm measuring-rod).

From the official weight of the Zurich sample - 52.8 mg - one can determinate the specific weight of the sample to be : 25.8 mg./(1.4 x 1.8) cm² = 20.95 mg/cm².

This is NOT comparable with the OFFICIAL specific weight of the Shroud : 23 mg/cm².

Reading all these reports leads to confusion because the Italian "experts" do prove in WRITING that they DO NOT AGREE on the correctness of the measurements and weights of the Shroud samples, as given in Nature and by Zurich.

Please note that the weights and sizes for the TWO Arizona samples, given by the TWO Italian experts (?) ARE NOT COMPATIBLE. One (or both ?) must be wrong ! The original text "A strip of 1 cm x 7 cm" is in accordance with the first measures given by Riggi: "*The strip of 8 cm² was reduced to 7 cm², because of the contamination of the linen by threads of other nature that could influence the dating. The three samples were cut from the strip of 1 x 7 cm.*" A theoretical weight of 7 cm² x 23 mg/cm² = 161 mg.

Dr. Tite said that he wrote down this value in the Nature report, written from memory, without reading the later published Riggi-Testore reports !

Let there no doubt, that if one makes the same "mistakes" in any kind of legal investigation or doping control, one will endanger the validity of the whole examination.

Line 11072

The samples were then taken to the adjacent "Sala Capitolare", where they were wrapped in aluminium foil and subsequently sealed inside numbered stainless steel containers by the Archbishop of Turin and Dr. Tite.

Samples weighing each from two of the three control samples were similarly packaged.

The three containers containing the Shroud (to be referred to as sample 1) and two control samples (samples 2 and 3) were handed over to the representatives of the three

laboratories, together with a sample of the third control (sample 4), which was in the form of threads.

All these operations, except the wrapping of the samples in foil and their placing in containers were fully documented by video film and photography.

Note 4 :

The Riggi report specifies : "*All operations were conducted in the presence of about 30 persons except for the [MESCOLAMENTE] mixing of the fragments, made by persons above any suspicion IN A SEPARATE ROOM."* (In casu the Cardinal, Dr. Tite and probably also Prof. Gonella and Prof. Riggi who entered the room for a short time.). One may wonder, why the MIXING and WRAPPING was not recorded by video and/or photography.

Answer : To secure the blind testing, where it was already decided to abandon blind-test procedures in the interests of effective sample treatment !

The story of sample 4, appearing out of nowhere, fits in the series of "protocol" violations! Because Prof. Riggi was unaware of this "sample 4", he had prepared only 3 x 3 stainless containers. Even stranger, despite the fact that he first refused to accept this mysterious sample, Prof. Riggi does not even mention sample 4 in his initial report !

Dr. Tite, the man who ordered the sample, was surprised because he did not expect Vial to show up with the sample he himself had requested !

I will quote again from the original Riggi text :

"Following the same criterion (Samples weight > 50 mg) three fragments were prepared out of each of the TWO control samples 2-3 brought by Dr. Tite, who did NOT know the origin and age, to assure TRIPLE BLIND experiments, as decided during the meeting in 1986."

How this "sample 4" has been accepted by Riggi and the Church authorities is still a mystery!

Afterwards, it became known that it was Dr. Tite who had specifically asked for a FOURTH control sample ! After some problems and with the help of Prof. Evin, the sample, in the form of threads was taken from the cape of St. Louis d' Anjou, located in the basilica of St. Maximim (France).

Anyway, the choice by Dr. Tite of this sample, dated 1290-1310 AD, indicates clearly that he, who was supposed to be NEUTRAL, was influenced by the ARBITRARY opinion that the Shroud originated in the same era.

This fourth sample, in the form of threads, was brought to Turin by the French textile expert Vial and Prof. J. Evin, a French radiocarbon expert from Lyon. This non invited man, not named in any report, said that he brought this "last minute" parcel because he did not trust the Italian mail... No one knows for sure how, when and by whom this sample has been introduced to the Cardinal. According to L'Osservatore Romano of 23-04-1988 : "*ALL operations were video-recorded and fully documented by photography*".

Line :11085

The laboratories were not told which container held the shroud sample. Because of the distinctive 3 to 1 herringbone twill weave of the Shroud could not be matched by the controls, however it was possible for a laboratory to identify the Shroud sample. If the samples had been unravelled or shredded, rather than being given to the laboratories as a whole piece of cloth, then it would have been much more difficult, but NOT impossible, to distinguish the Shroud from the other samples. (With unravelled or shredded samples pre-treatment cleaning would have been more difficult and wasteful).

Because the Shroud had been exposed to a wide range of potential sources of contamination and because of the uniqueness of the sample available, it was decided to abandon blind-test procedures in the interest of effective sample treatment. But the three laboratories undertook not to compare results until after they had been transmitted to the British Museum. Also, at two laboratories (Oxford and Zurich), after combustion to gas, the samples were recoded, so that the staff, making the measurements did not know the identity of the samples.

Note 5 :

Radiocarbon experts are probably not textile experts. Textile expert Prof. Raes was not able to identify the Shroud sample from the side strip sample in 1973, because his samples were to small ! Note well, that he was working on samples about 3 times larger than the ones examined by the radiocarbon experts.

Anyway, the Dr; Tite did not search in the Bock catalogue of the Victoria and Albert Museum. There several 3/1 herring bone linens are registered! Here one must come to the conclusion that the authors of this report have little laboratory sampling experience. In fact, Prof. Gove proposed this sampling method to assure a REPRESENTATIVE sample by taking THREADS from different parts of the Shroud !

None of the laboratories did make any observation against sample 4, being in the form of threads. Following the Riggi-report, Dr. Tite, who held the two control samples, did not know the origin and dating of the samples. This means that the decision to abandon blindfold-test procedures was already taken BEFORE April 21, without the consent of Prof. Riggi or any other Church authorities.

Experts know that blindfold-test procedures are mandatory to assure correct application of the procedures and consequently correct results. One may wonder about "leaks" between the parties involved.

One may not forget the close relationship between Oxford and the British Museum. Prof. Hall of Oxford was at that time a member of the board of the British Museum. Dr. Tite, the representative of the British Museum, was chosen to replace Prof. Hall and he is now still working for Oxford University.

Recoding of samples and blind testing are normal laboratory practices. But one may wonder, why BLIND testing was decided at the Trondheim Conference for the "International Collaborative Programme". Blind testing means that NO ONE knows if the sample is yes or no REPRESENTATIVE or a DUMMY. For the same reasons, PLACEBO samples are used by medical tests. Some patients do indeed react on placebo medicaments.

CONTROLS

The three control samples, the three approximate ages of which were made known to the laboratories, are listed below. (Only sample 3 is discussed).

Note 12 :

Again one may wonder why this was done. Normally, NO INFORMATION of any kind should have been given and the possibility of a placebo-sample should have been left open to ensure that nobody did bias the results.

(Line 11089) Sample 3 :

Linen from the collection of the Department of Egyptian Antiquities at the British Museum, associated with an early second century AD mummy of Cleopatra from Thebes (EA 6707). This linen was dated in the British Museum Research Laboratory, using liquid scintillation counting, giving a radiocarbon age of 2010-+80 yr BP (BM 2558). This corresponds to a calendar age of, rounded to the nearest 5 years, 110 BC - 75 AD. (68% confidence level).

*** Note 13 :**

The identification of this mummy is not certain. Cleopatra of Thebes was a young girl, who lived and died at age 11, in the time of emperor Adrian (117-138 AD). The calendar age 9-78 AD, given by the British Museum, is not conform.

MEASUREMENT PROCEDURES

Because it was not known to what degree dirt, smoke or other contaminants might affect the linen samples all three laboratories subdivided the samples and subjected the pieces to several different mechanical and chemical cleaning procedures. All laboratories examined the textile sample microscopically to identify and remove any foreign material.

*** Note 14 :**

None of the laboratories reported contamination. But one can read in the "thanking list" at the end of the Nature report, the following "strange" sentence : "*Oxford thank P.H.South (Precision Processes Textiles) Ltd, Derby, for examining and identifying the cotton found on the Shroud sample.*"

In "Textile Horizon" the story is told as follows : "*Prof. Hall noticed two or three strange fibres... In Derby the minute samples, looking like human hair were magnified 200 times under a microscope and identified as COTTON. Possibly of Egyptian origin and quite OLD.*"

One may wonder how these strange fibres came on the Shroud ! Was it during repairs or became it simply bound in when the fabric was woven ? Later, Arizona noticed the presence of some minute BLUE and RED fibres, probably silk from the RED protecting cloth or the BLUE SILK strip, sewn along the edges of the Shroud. Because the "purity" of the Shroud samples is strange, I asked Dr. Woeflfi (Zurich) some explanation. He assured me : "*Under the microscope, the Zurich sample did not show any contamination.*"

Very STRANGE indeed, because the Italian experts reported heavy contamination of the Shroud by pollen and fungi. Other experts have also reported heavy contamination. Dr. Garza-Valdes, a microbiologist and archaeologist, examined in 1993, with the help of Prof. Riggi, a (non-official) Shroud sample and said : "*As soon as I looked at a segment in the microscope I knew that it was heavily contaminated.*"

Radiocarbon expert Prof. Gove looked also through the SAME microscope and he said : "*This not a crazy idea. A swing of 1000 years would be a big change, but it's not widely out of the question and the issue needs to be resolved*".

Dr. Donahue of Arizona University, one of the authors of the radiocarbon dating of the Shroud, said :"*I am a bit sceptical, but I don't want to dismiss the theory. It is possible that contaminants could throw off the dates somewhat but by how much?*" Can this explain the rc. dating for the Shroud ?

Another possible contamination by "bio-fractionation" of the isotopic composition of carbon, by microbes in the air, has been described by Kouznetsov et al. in "Textile Research Journal" (Vol. 66 Nr 2 February 1996)|.

A laboratory model was set up to evaluate the possible microbial impact on cellulose during long term contact with air micro-organisms. The SAME experiments were conducted simultaneously in TWO places : Moscow and Anapa Beach, -+ 1300 km from each other. These experiments do show a marked methylation/acetylation of cellulose but only a slight CHANGE in isotope content, in function of the protein contamination level and the geographical / ecological region. In fact in Anapa Beach air promotes mostly acetylation and the Moscow air mostly methylation.

In particular this leads to a significant concentration of 13C and 14C by bacteria comparable to the surrounding water and atmosphere. It implies the incorporation of extra atoms of 13C-14C into the cellulose. Since 13C and 14C values are very critical for accurate radiocarbon

dating of archaeological textile samples, this data might be useful for corrections to radiocarbon dating.

Line 13049

Each laboratory measured the graphite targets made from the textile samples, together with appropriate standards and blanks, as a group (A RUN).

Each laboratory performed between 3 and 5 independent measurements for each sample which were carried out over a time period of about one month.

* Note 22 :

Arizona started measurements last week of May. Zurich communicated its results to the British Museum early July. Oxford begun the measurements of the samples, July 20, AFTER the results of Arizona and Zurich were known at the British Museum. A time period of about TWO months !

Line 13054

The results of these independent measurements (Table 1) in each case representing the average of several replicate measurements, made during each run, are measured sequentially, the sequence being repeated several times.

* Note 23 :

Let me translate this "AMS technology" as simple as possible in human language. Beta-counters measure the radioactivity by counting the number of pulses, caused by the disintegration of the radioactive carbon isotopes : 14C + n ==> 14N + e

Normally ONE run (for older samples of several weeks) is made, but it is normal practice to make at least TWO runs.

In AMS the number of isotopes 12C, 13C and 14C are ACTUALLY separated and counted. Not the number, but the isotope ratios C14/C12 and C13/C12 will be used for further calculations. Today, laboratory results are given in fractions of modern carbon 14.

To avoid any confusion, I will follow a text about the Zurich AMS radiocarbon dating facility: "*Samples prepared from 1.6 ml STP CO2 gas yield good beams of about 15 Mu-Ampere for approximately 1 h. Currently, about 25% of the negative carbon isotopes produced in the ion source, reach the final detectors. The error of calibration, based on TWO NBS standards is -+0.3%. Typical background for dead carbon is 2% of modern carbon. But if samples are prepared with silver powder the back-ground error becomes as low as 0.4%. This enlarges the range to 45,000 rc. years, which is important for very old samples.*"

Because only a tiny fraction of the carbon isotopes are counted, the measured ratios 14C/12C, 14C/13C and 13C/12C are compared to modern carbon NBS STANDARD ratios :

$$14C/12C = 1.15 \times 10^{-12} \quad 14C/13C = 1.27 \times 10^{-10} \quad 13C/12C = 1.11\%$$

This means that for ONE single 14C isotope there are :

-+ 8.695.652.000.000 12C particles

-+ 96.521.730.000 13C particles

But this is misleading !

One mol of CO2 gas contains 12000 milligrams of PURE carbon, with a volume of 22400 millilitre (STP) Thus a target, prepared from 1.6 ml. CO2 contains (12000 x 1.6)/22400 = 0.857 mg PURE carbon.

Number of carbon isotopes in a target of 0.857 mgr :	45.064.000.000.000.000.000
12C =	42.590.543.249.951.020.876
13C =	473.706.749.980.000.000
14C =	48.979.124

The carbon targets are one after the other "bombarded" with a beam of caesium particles. The impact of this beam causes the shattering of a SMALL fraction of about 0.000245 mg, containing -+ 14000 14C isotopes. This mixture is accelerated and brought under the influence of variable magnetic fields into orbit, where the heaviest 14C isotopes will be in the outer lane. Only about 1/4 of the isotopes "on the loose" reach the final counting devices. (In reality, AMS is a much more complex matter).

It is clear that counting and systematic errors can cause large errors. Therefore, from the pure carbon series of (10...20) of small "targets" are prepared. During each "RUN", 10...20 targets are measured one after another (sequentially), together with 1 or 2 sets of NBS standard and blank control-samples.

Each measurement takes about 10 seconds. The RAW results are stored in a computer. Each "independent measure" is the averaged result of the "dependent" results of 1, 2, 3 or 4 runs. The number of runs depend on the importance of the sample.

This means that the Shroud has been measured at least 120 times. Assuming that every laboratory made at least TWO runs for each sample, 240 single measurements were made.

The question is how large was the scatter among the single measurements ? Were there no outliers ? None of the laboratories gave an answer to this question.

Line 13064

The conventional radiocarbon ages were all calculated using the procedure suggested by Stuiver & Polach. (Radiocarbon 19 1977), with normalisation to delta 13C -25o/oo, and were reported accordingly in yr.BP. (years before 1950).

*Note 25 :

Normalisation for delta 13C is necessary because there is a DIFFERENCE between the concentration in 13C AND 14C in the atmosphere and in living matter.

Based on the ACTUAL MEASURED -d13C value, assumed to be CONSTANT, the -d14C at ORIGIN is ESTIMATED. The EMPIRICAL relationship is : -d14C = ((2 x -d13C) o/oo. In practice the corrected NBS standard value = NBS x 0.95. Recent 13C measurements in plants indicate that the concentration in 13C is NOT CONSTANT. Vogel et al. reported significant differences in 13C for African plants, with a C3 and C4 photosynthesis. The delta 13C varies from -9 o/oo till -36 o/oo. Van der Merwe reported differences in 13C in the leaves of the same tree in function of the height and also in human skeletons. The University of Victoria (Canada) uses the LARGE differences in the ratio C13/C12 to determine the origin of crude oils.

Dr. Kouznetsov (Moscow) examined Russian and Siberian RAW flax and found that 13C and 14C concentrations are NOT constant in the FIVE main components of raw flax.

Line 13067

The errors, which are quoted in Table 1, at the 1 sigma level (sigma = standard deviation) include the statistical counting error, the scatter of results for standard and blanks and the uncertainty in the d13C determination. (Arizona includes the d13C error at a later stage, when combining sub-samples results. Oxford errors below 40 yr are rounded up to 40.)

Note 26 :

One probably was confused by the combination of TWO different weighing systems, using DIFFERENT notations. The standard deviation is calculated in function of the scatter.

The errors given in Nature are QUOTED errors, a combination of counting, systematic and errors in the d13C determination. Wilson & Ward use indeed other notations :

Mean RC. age =   Pooled Age.

Variance =   the inverse value of the sum of the inverse squared individual errors

Error =   Square root out of the variance..

Chi^2 =   Test statistic

The remark about the Arizona d13C was very confusing.

Because the quoted errors for Arizona are rather small, I first thought that the correction for d13C was not included in the errors quoted in Table 1, but was included at a later stage, when combining sub-samples, resulting in the error on the mean : 647-+31

Strictly following Wilson & Ward : 646-+17 This gives a estimated correction for delta 13C : 31^2 - 17^2 = (d13C)^2 => (961-289)^0.5 = 26. A rather high value, in regard that the measured d13C value given i

For Tables 1-2-3 and graphs 1-2-3. See special page

Note 28 :

Comment on the number of Arizona samples.

One should expect some explanation for the fact that Arizona only gives FOUR dates for sample 1 (the Shroud) and FIVE for the other samples. Did they also destroy a sample during pre-treatment ? I asked Dr. Tite's opinion about this.

The answer was too simple :"*Because in Arizona one thought 4 datings were sufficient...*"

RESULTS. (Line 14002)

On completion of their measurements, the laboratories forwarded their results to the British Museum Laboratory for statistical analysis.

Note 30 :

The reason for statistical analysis is the FACT that radioactivity is in essence a statistical problem. Wilson & Ward proposed a new method, based on the assumption that the weighed means are proportional to the inverse squared errors quoted by the laboratories. (Archaeometry 20 p. 19-31 1976). The analysis, given in Nature, has been performed following this method by Dr. Moven Leese (British Museum).

IF MADE IN BLIND, STRICTLY FOLLOWING THE PROPOSED WILSON & WARD PROCEDURE AND USING SOLELY THE DATES GIVEN IN TABLE 1, ANY STATISTICIAN MUST FIND THE SAME RESULTS AND COME TO THE SAME CONCLUSIONS.

Line : 10445

The individual results, as supplied by the laboratories are given in Table 1.

Each date represents a unique combination of pre-treatment and measurement run and applies to a SEPARATE sub-sample, except where indicated by the identification code.

From these data it can be seen that there are NO SIGNIFICANT differences between the results obtained with the different cleaning procedures that each laboratory used.

Note 32 :

This is a little bit strange. Remark sub-sample O2.2b where it is clearly indicated that there is a significant difference between the six replicates !

The mean radiocarbon dates and associated uncertainties for the four samples as supplied by each of the three laboratories are listed in Table 2 and shown in figure 1.

Also included in Table 2 are the overall unweighted and weighted means, the weights being proportional to the inverted squared errors as quoted by the laboratories.

Note 32 :

Despite all my research and several letters to the British Museum I still do not know how one did "BIAS" the REAL Arizona-error from 17 into 31 ! Based on the scatter, the error = 28.

Line 13040-b

The underlying principle of the statistical analysis has been to ASSUME that, unless there is strong evidence otherwise, the quoted errors FULLY reflect all sources of error and that the weighted means are therefore APPROPRIATE.

An initial inspection of Table 2 shows that the agreement among the three laboratories for samples 2, 3 and 4 is exceptionally good.

The spread of the measurements for sample 1 is somewhat greater than would be expected from the errors quoted.

Note 33 :

Here I was wondering HOW the British Museum and also Prof. Bray did verify the dates forwarded by the laboratories and given in table 1. I still wonder why Prof. Bray did not spot, at his initial inspection of Table 1, that the Arizona errors for the Shroud ARE very small... and that the large error given in Table 2 is clearly not COMPATIBLE with the errors in Table 1.

Line 13048-b

More quantitatively, to establish whether the scatter among the three laboratory means was consistent, with their quoted errors, a X^2 (Chi^2) test was applied to the dates for EACH sample, in accordance with the recommended procedure of Ward & Wilson. (Archaeometry 20. 1978)

Note 34 :

Strangely, the Chi^2 intra-laboratory results are NOT given in Table 2, where one finds only the Chi^2 test result for the inter-laboratory MEAN result. Why ? Based on the data given in Tables 1 and 2.

Arizona : 8.67 > 7.81 = REJECT Oxford : 0.67 < 5.99 = OK Zurich : 2.74 < 9.49 = OK Conclusion : The Arizona results are NOT consistent.

I asked Dr. Tite about this... He wrote :"*On finding INCONSISTENCY, one did decide to REWORK the dates and also, because of the small number of laboratories, NOT to reject any particular laboratory*" (Private communication).

Line 13052-b

The result of this test, given in Table 2, show that it is UNLIKELY that the errors quoted by the laboratories for sample 1 fully reflect the overall scatter.

The errors might still reflect the uncertainties in the three dates relative to one another, but in the absence of direct evidence on this decided to give the three dates for sample 1 EQUAL weight in determining the final mean, and to estimate the uncertainty in that mean from the scatter of results.

*Note 35 :

One may wonder, what "uncertainty" really means ? Here one tries to AVOID to state the FACT that the REAL calculated UNBIASED Chi^2 test value is 8.56, much larger than the Chi^2 value 6.4 given in Table 2.

Because the MAXIMUM Chi^2 test value for THREE laboratories and 95% confidence is 5.99, a CALCULATED Chi^2 test value 8.56 > 6.4 > 5.99 must be rejected.

Line 13060-b

As shown in Table 2 the unweighted mean of the radiocarbon age of sample 1 and its uncertainty are : 691-+31 rcy BP.

Confidence limits for sample 1 were obtained by multiplying the uncertainty by td, the value of a Student's t distribution, with a (n-1) degrees of freedom, at the appropriate probability level. The value of d, which lies between the inter- and intra-laboratory degrees of freedom (that is between 2 [3-1 labs] and 9 [12 measurements - 3 laboratories], was estimated at 5, on the basis of an analysis of variance on the 12 individual measurements supplied by the laboratories.

*Note 36 :

Here one forgets that any INDEPENDENT result, given in table 1, is the AVERAGED mean of at least TEN measurements. One should have used the normal factor 1.96. This is clearly a side-step to enlarge the limits from 13 x 1.96 = 25.5 to 31 x 2,6 = 80.6 yr.rc. The only purpose of this "artifice" is to enlarge the error range, so that practically all dates -+ error are covered !

<center>Real 95 % Confidence range..</center>

<center>Arizona 647 < ===== 672 ===== > 697 Oxford</center>

<center>590+30=620   795-65=730</center>

<center>606+41=647</center>

<center>610 <=============== 691 ===============> 772</center>

<center>Biased 95 % confidence range.</center>

But as stated before, because of the small number of laboratories the British Museum did not like to reject any laboratory. And so the dates were reworked and the 95% limits were biased from 672-+26 tot 691-+81 !

Line 13067-b

Individual measurements from a particular laboratory were weighted according to their inverted squared errors but the contributions from different laboratories were weighted equally, thus ensuring consistence with Table 2.

Thus for sample 1, where the error has been ESTIMATED from the scatter 68% and 95% confidence limits for the TRUE radiocarbon date were found from the 1.1 and 2.6 sigma errors about the unweighted mean, respectively, the multiplying factors being obtained from standard tables of the t5 distribution.

However, for samples 2, 3 and 4 the limits were obtained in the usual way, from the 1 sigma and 2 sigma quoted errors about the weighted means, assuming normality.

Note 37 :

One may assume that if the means for sample 2, 3 and 4 have been obtained in the usual way, the mean for sample 1 has been obtained in a unusual way, assuming abnormality...

Note 38 :

Comparing the results of the British Museum (Col.1) with the computer results (Col. 3) shows a SIGNIFICANT DIFFERENCE for the mean radiocarbon ages. One may wonder how this is possible. Was my computer tilt ? Did the British Museum not calculate correctly? Were the results a little bit "adjusted" ? Naturally, one may argue that all these "little" adjustments are only of small interest. But if one looks closer, one will detect a well defined pattern towards a well determined goal ! We already know about the "combination" of the Arizona dates and the "reworking" of the error from 17 to 31. This "artifice" shifted the mean from 672 to 689, much closer to the Oxford dates. By shifting from the REAL mean 672-+13, strictly following Wilson & Ward, to the BIASED mean 689-+16, one shifts the REAL Chi^2 : 8.56 to the value 6.4 given in Nature.

Nature : Basis Table 2   Computer : Basis Dates Table 1

$$\frac{(750 - 691)^2}{30^2} + \frac{(691 - 676)^2}{24^2} + \frac{(691 - 646)^2}{31^2} = 6.34 \qquad \frac{(750 - 672)^2}{30^2} + \frac{(676 - 672)^2}{24^2} + \frac{(672 - 646)^2}{17^2} = 8.56$$

Chi^2 test values higher than the critical value, here 8.56 > 6.4 > 5.99 do indicate that the dates under examinations are NOT CONSISTENT.

To eliminate any doubt, about the determination of the % significance level, the mathematical formula is given :

-[Chi2/2] -[8.56/2]

Significance = e = 2.718 = 1.2%

This means, that there are only 12 chances in 1000, that the dates for the shroud are NOT consistent. Even with the tabulated Chi^2 value 6.4, the % Sig. Level is 4.4% and not 5% as INCORRECTLY stated in Table 2 of Nature.

A NEGATIVE Chi^2 is proof, that the dates under examination are NOT CONSISTENT. In such cases, it should have been wise, to follow the advice, given by Prof. Hoel (University of California) : "In the case of a Chi^2 test CLOSE to the LIMIT, it is better not to draw conclusions, but to search for more and better data and to examine the reason of non consistency."

Probably, nobody in team of the British Museum did read the advice of Prof. Hoel, because despite of a Chi^2 test not close to, but FAR OVER the limit, one converted these non consistent data into CONCLUSIVE EVIDENCE !

It seems unbelievable, that such error in judgement, was not spotted by the peers or referees, which normally do assure the scientifically standard of the well known paper Nature.

One may wonder, why neither Prof. Bray and Prof. Gonella advisor of Cardinal Ballestrero, did not spot this flagrant example of BIASING..

The answer of the British Museum reads as follows : "Your calculations are correct. The differences between Yours and our results are due to the use of different weighting systems". Because I used the recommended Wilson & Ward method, one may wonder, which method was used by the British Museum.

*****

According to the Nature report "*The result if the Chi^2 test show that it is unlikely, that for sample 1, the quoted errors fully reflect the overall scatter.*" But by how much ? Because if one assumes that the 12 dates for sample 1 are exact measurements, then one assumes also that the quoted errors are NOT correct.

From the Chi^2 tests for samples 2, 3 and 4, one can make a scientifically sound estimation. The "quoted errors" for sample 1, will be step by step enlarged to obtain the Chi^2 values for samples : 2 (0.1), 3 (1.3) and 4 (2.4)

Errors on the mean.

Sample	Chi^2	Arizona	Oxford	Zurich
1	8.56	17	30	24
1	6.34	31	30	24
4	2.4	51	50	39
3	1.3	69	66	53
2	0.1	248	240	192

One also can estimate the errors for the sub-samples.

Errors to obtain a Chi^2 value of 2.4, 1.3 or 0.1

Arizona				Oxford				Zurich				Chi^2	% S.L.
701	690	606	591	795	745	730	733	722	676	639	635	Chi^2	% S.L.
33	35	41	30	65	55	45	61	56	51	45	57	8.56	1.2
60	64	75	55	-	-	-	-	-	-	-	-	6.34	4.4
99	105	123	90	108	92	75	99	91	83	73	93	2.40	30.0
134	142	168	122	143	121	99	136	124	113	99	126	1.30	50.0
482	510	604	438	520	440	360	493	449	301	359	456	0.10	90.0

In other words, to obtain the SAME Chi^2 test value for the Shroud, as for sample 2, the errors have to be enlarged by a unlikely high factor.

For a 90 % sig. level, the rc. age range becomes about 1300 years !:

Oxford : 795+520 = 1315   Arizona : 606-604 = 2

To prove that all calculations are correct, a Chi^2 test will be performed for a significance level of 90 %:

Arizona : $(689-646)^2/248^2$ = 0.0300

Oxford : $(750-689)^2/240^2$ = 0.0640

Zurich : $(689-676)^2/192^2$ = 0.0046

Chi^2 test value   = 0.0986   = 0.1

Line 17068

No additional uncertainty has been added to take account of the short growth period of textile samples. There is little published guidance on this, although it has been suggested that 15 years should be added in quadrate to the overall uncertainty in the radiocarbon date for samples of growth period of less than one year, such as linen.

*Note 39 :

Although correct, this is a strange remark. In the Wilson & Ward paper TWO methods are given. Case 2 takes into account the uncertainties due to natural phenomena, solar activity and the kind of material. Following Wilson & Ward, these uncertainties are many times UNDERESTIMATED. The addition of this "additional uncertainties" is calculated as follows :
$(E^2 + A^2 + X^2)^{0.5}$ = total error.

Line 17059-b

The results, together with the statistical assessment of the data, prepared in the British Museum, were forwarded to Prof. Bray of the "Istituto di Metrologia G.Colonetti" (Turin), for his comments. He confirmed that the results of the three laboratories were mutually compatible, and that, on the evidence submitted, none of the mean results was questionable.

*Note 41 :

Here the authors of the Nature-report did not use the exact words used by Prof. Bray. Did they "edit" the text of Prof. Bray, because of his not correct English ? Compare the text in Nature with the comment of Prof. Bray : "no average result APPEARS questionable." In Nature : "none of the mean results WAS questionable."

And with a gentle "grammatical" touch, the sense of "appears" is twisted in to "was". In fact, Prof. Bray did make a lot more remarks, about the report, than published in Nature ! Here follows his comment in own words :.

"Account being taken only of the FINAL REVISED report obtained from Dr. Tite of the British Museum, the following comments can be made :

1) The results of the three laboratories are mutually compatible.

2) On the evidence submitted no average result appears questionable.

3) The scatter of measurement values for samples 2, 3 and 4 is within the limits established for the method adopted, whereas for sample 1 the scatter is about equal to that limit value.

4) The difference results (even if not large) obtained for the examined samples show that the interference factors caused by sample preparation or due to the procedures for the application of the measurement method have influenced sample 1 to a greater extent. Probably, the scatter concerning sample 1 could have been reduced by establishing :

   a) A common testing procedure and sample treatment and cleaning to determine universally the state of the measures.

   b) Testing conditions.

   c) The conditions of the measurement means on the basis of reference values to be chosen with equal spacing.

   d) The methods for evaluating measurement data and the associated uncertainty. These above comments give special attention to the meteorological aspects of the

carbon 14 method. They do NOT take into consideration the choice of the measurement method adopted and of the samples to be tested, because I was not involved either in test planning or in the choice of the samples.

CONCLUSIONS :

The result of radiocarbon measurements at Arizona, Oxford and Zurich yield a calibrated calendar age range with at least 95% confidence for the linen of the Shroud of Turin of AD 1260-1390 (rounded down/up to the nearest 10 yr). These results therefore provide CONCLUSIVE EVIDENCE that the linen of the Shroud of Turin is mediaeval.

The results of radiocarbon measurements from the three laboratories on four textile samples, a total set of twelve data sets, show that none of the measurements differs from its appropriate mean value by more than two standard deviations. The results for the three control samples agree well with the previous radiocarbon measurements and/or historical dates.

*Note 41 :

This is really "jumping to conclusions". Without any new evidence one declares a non existent "95% confidence" to be "conclusive evidence". Solely on the basis of the dates given in table 1, any computer program will show that the their is only a probability of 1,2% that the inter-laboratory results are CONSISTENT. From the Chi^2 tests (See Note 38) one can verify that these statements ARE NOT correct.

<center>END</center>

PART III

A CRITICAL REVIEW

Like many other sindonologist, I studied the Nature report. My eyes were caught by some strange facts: Oxford gave FOUR times the SAME d13C value of -27 o/oo, a very low value for linen. Normally 23-25 o/oo. Arizona obtained VERY low errors and only gave FOUR sub-results for the Shroud and FIVE for the other three samples. Without any explication.

There was also the strange remark :"Arizona includes the d13C error correction at a later stage." I asked Dr. Donahue of Arizona, but he did not reply. Dr. Tite replied that he thought that Arizona thought that FOUR samples were enough...

Another problem was the fact that when I entered the Nature data given in Table 1 in my scientific calculator, the results were NOT the same values as given in Table 2 of Nature.

Table 2	Nature	Calculator.
Arizona	646-+31	647-+28
Oxford	750-+30	757-+20
Zurich	676-+24	682-+20
Mean	689-+31	

Because I was puzzled by these strange results I decided to verify the statistical analysis. Therefore I used the method given in Perry's Chemical Engineering Handbook, my technical bible. The reader is referred to any text-book on statistical analysis.

Here the more powerful F-test value is used, instead of the Chi^2 test.

The F-test, for the Shroud, is based on the THREE mean results obtained by the laboratories and the TWELVE independent results taken from Table 1 in Nature. Here the quoted errors will have NO influence. For 95% confidence and (3-1)-(12-3) degrees of freedom, the MAXIMUM F-value, taken from statistic tables is 4.26.

I found a F-value of 4.7 >> 4.26, consequently the reported data are NOT CONSISTENT. Such data should not be used in any further calculations.

THE COMPLETE CALCULATIONS WILL BE GIVEN IN THE CHAPTER ON STATISTICAL ANALYSIS.

I asked Dr. Tite to explain these SIGNIFICANT differences. The reply was simple :"*These differences are due to the fact that Dr. Morven Leese, a member of the British Museum staff, who performed the statistical analysis, did not use the classical method, but a specific method for the comparison of radiocarbon dates, developed by the Australian scientists Drs. Wilson & Ward.*"

<div align="center">END</div>

APPENDIX

FACTORS AFFECTING RADIOCARBON DATING

The production and/or decay of 14C has probably been influenced by unknown natural phenomena, related to the changes in the earth's orbit around the sun and variable sun activity. It is clear that long periods of low and high solar activity can have a significant influence on plants with a short growing period such as flax.

For flax, an annular plant with a short growing period, one must take also in account the countless HOLLOW tiny strands. Flax fibres have a LARGE INTERNAL area and are very good absorbents for all kinds of contamination.

Contamination of the INSIDE surface of the tubes is difficult to detect and even more difficult, if not impossible to remove. In ancient times CRUDE flax remained a long time in flowing river water, during the so-called "RETTING" process. Scientifically one says that these dates are not distributed normally and are not consistent.

Examples of "normal distributions" are Gauss and Poisson "clock" patterns. Before dates are to be assessed by statistical analysis, they must have been tested for compatibility or consistency. One may wonder if the authors of the Nature report did examine whether some observation(s) is/are likely to be outlier(s).

According to Prof. Hoel (University of California) : "*In the case of a Chi^2 test value, CLOSE to the MAXIMUM, one should NOT draw any conclusions, but ask for more and better data.*"

The authors of the Nature-report probably did not know this wise advice.

They also "forgot" to mention the FACT that the Chi^2 value given in Table 2, biased from 8.56 to 6.4, is not CLOSE to, but LARGER than the CRITICAL Chi^2 test value.