

SCIENCE SEEKS
TO SOLVE...

The Mystery of the Shroud

THEY CALL IT the Shroud of Turin. You may never have heard of it; few had, until recent years, outside of Italy. Yet this treasured strip of linen cloth—an object of veneration by millions—is one of the most perplexing enigmas of modern times. It is, in fact, the focus of an intensive scientific investigation that reads like a mystery story.

The curious blend of history and legend behind that story glitters with kings and dukes, crusaders and popes, and perhaps a consummately clever charlatan. The modern detectives probing the mystery include art historians, pathologists, linguists, biblical scholars, textile experts, chemists, physicists, and photographic specialists.

Among the clues to the riddle are such bizarre items as a Roman whip, wizened specks of pollen, bones from a Jerusalem cemetery, and photographs enhanced by space-age instruments designed to study the moon and Mars.

But the clue that transcends all others is the remarkable image on the shroud itself—a ghostly image, life-size, of an unclothed, bearded man with long hair.

The face, hauntingly serene in death,



By
KENNETH F. WEAVER
SENIOR ASSISTANT EDITOR

1980



© 1980 DAVID DOYLE

Carving in cardboard reveals the three-dimensional quality of the face on the Shroud of Turin. The linen cloth bears the full-body image of a crucifixion victim that some believe to be that of Jesus of Nazareth. A computer

density scan of a photograph of the face enabled scientists to plot true-to-life relief, normally an impossibility. Examination of the shroud with space-age technology may help determine how the image was formed.



GALLERIA SABAUDA, SCALA/EPA INC.

Miracle, forgery, or natural phenomenon? The shroud has provoked controversy since its first recorded display in France in the 14th century. Its previous history can only be theorized. New Testament accounts of Christ's Crucifixion mention a linen cloth in which His body was wrapped. A 16th-century painting (right) attributed to Giovanni Battista della Rovere suggests how the cloth would have been draped to achieve front and back images. The shroud has been housed in the Italian city of Turin since 1578.





GIANNI TORTOLI (ABOVE AND BELOW)



Public display of the shroud in the fall of 1978, only the third in this century, drew more than three million people to the Cathedral of San Giovanni Battista (left). The baroque chapel rising above the cathedral normally safeguards the relic. During the six-week exposition steel and bulletproof glass encased the shroud (above). Celebrating Mass, the Archbishop of Turin and custodian of the shroud, Anastasio Ballestrero, raises the Communion wafer.

would grace a masterpiece of art. The body, anatomically correct, bears the frightful marks of scourging, crucifixion, and piercing—perhaps by thorns and lance. It would appear to be a portrait, uncannily accurate when matched against the Gospel accounts, of Jesus of Nazareth.

And, indeed, some believe that this stretch of ivory-colored linen is the very cloth that Joseph of Arimathaea placed under and over the body of Jesus in the rock-cut tomb near Golgotha nearly 2,000 years ago.

Did a Crusader Acquire Relic?

Undisputed records go nowhere near that far back. The shroud first emerges on the stage of history in the mid-14th century, in the town of Lirey, France. Its owner was a famed knight, Geoffrey de Charny, seigneur of Lirey. Where and how he got the relic, no one knows, although there was talk of "spoil of battle."

A chronicler of the Fourth Crusade, Robert de Clari, had written of seeing in Constantinople, in 1203, a *sydoine* (shroud) that bore "the figure of our Lord." The following year, he recounted, it had disappeared when the crusaders looted the Byzantine capital. If the Lirey linen and the *sydoine* of Constantinople are the same, the secret went with de Charny to his grave.

A British writer, Ian Wilson, believes he can trace the shroud all the way from Jerusalem to Edessa (now the town of Urfa, Turkey), where an image-bearing cloth was famed, thence to Constantinople, and eventually to Lirey. But—as Wilson himself admits—the connections are exceedingly tenuous and circumstantial.

Over the years dozens of shrouds—some with images, some without—have been put forward as genuine. The 14th century, especially, was notorious for relic mongering, when chicanery and fraud abounded. So it is not surprising that the local bishop of Troyes denounced the Lirey shroud as false when it went on public exhibition in 1389. He cited the charge by a predecessor that, "after diligent inquiry and examination," he had determined that the cloth was "cunningly painted, the truth being attested by the artist who had painted it."

This judgment was, in future years, to provide ammunition for those who denied

the shroud's authenticity. But the Avignon Pope Clement VII ordained that the Lirey cloth could continue to be an object of devotion and pilgrimage so long as it was exhibited as a "representation" of the true shroud.

For reasons that are somewhat murky, de Charny's granddaughter, Marguerite, surrendered her prized possession to Louis, Duke of Savoy, in 1453. One 16th-century account, related by David Sox in his admirable book *File on the Shroud*, says that Marguerite "gave the cloth to Duke Louis because when she was returning to Burgundy the relic-bearing mule stopped at the gate of Chambéry [then capital of Savoy] and refused to budge." That explanation, says Sox, is as apocryphal as it is charming.

Whatever the reason, the shroud from then to this day has belonged to the House of Savoy. Duke Louis built a special church at Chambéry—the Sainte Chapelle—where the shroud was enshrined with honors from pope and pilgrim alike.

An incident at Chambéry in 1532 takes on special significance today. Fire broke out in the sacristy of Sainte Chapelle; before the shroud was rushed to safety, drops of molten silver from its casket dropped on the cloth and severely charred some of the corners of the folds. Water used to put out the fire left large and unsightly stains.

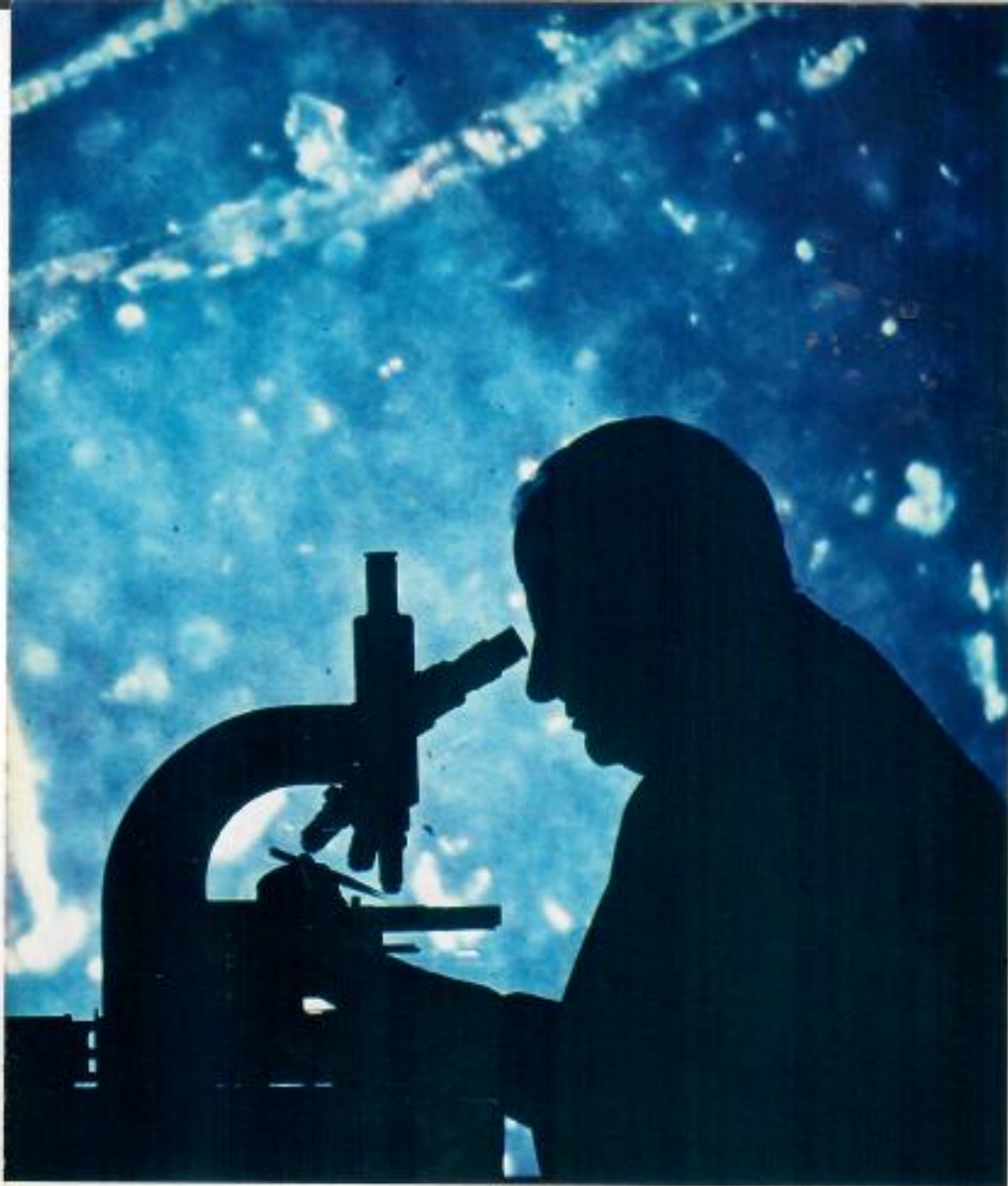
The damage, partially covered by patches, is all too evident, though fortunately the image was largely spared. As it turned out later, that fire provided valuable clues that scientists are now interpreting.

In 1578 the Duke of Savoy moved the shroud across the Alps to his new capital, Turin (Torino), in Italy's northwest region of Piedmont. Save for a period during World War II, it has been there ever since.

Four centuries passed, and, in 1978, the shroud was brought out for public exhibition to commemorate the anniversary of its arrival in Turin. It had not been seen in public display for 45 years, and only once before that in the 20th century, in 1931.

More than three million pilgrims came to Turin during the six-week exposition. Among them were several hundred shroud students and enthusiasts who call themselves *sindonologists* (from the Greek *sindon*, fine cloth). They compared notes during

(Continued on page 743)



SISSE BRIMBERS AND WALTER G. McCRONE (ABOVE); © 1982 BARRIE M. SCHWARTZ



*Image of body on
one side of shroud only*

COVER BY ELLEN SAFFORE
COMPILED BY DAVID B. MILLER
NATIONAL GEOGRAPHIC MAGAZINE

Anatomy of the shroud

THE MAN OF THE SHROUD, whatever his origin, bears obvious wounds of crucifixion, a practice outlawed in the Roman Empire in the fourth century A.D. Rivulets of "blood" that encircle the head and the heavy flow on the side recall the biblical crown of thorns and thrust of the centurion's lance during Christ's Crucifixion.

The life-size image, photographically enhanced here (right), actually appears as faint as an apparition (bottom). Scourge marks that pepper the body (diagram below) resemble the pattern inflicted by a

Notes in CAPITAL LETTERS refer to wounds associated with crucifixion.

BLOOD FROM NAIL WOUNDS IN THE FEET

Backing cloth; corner section of shroud missing

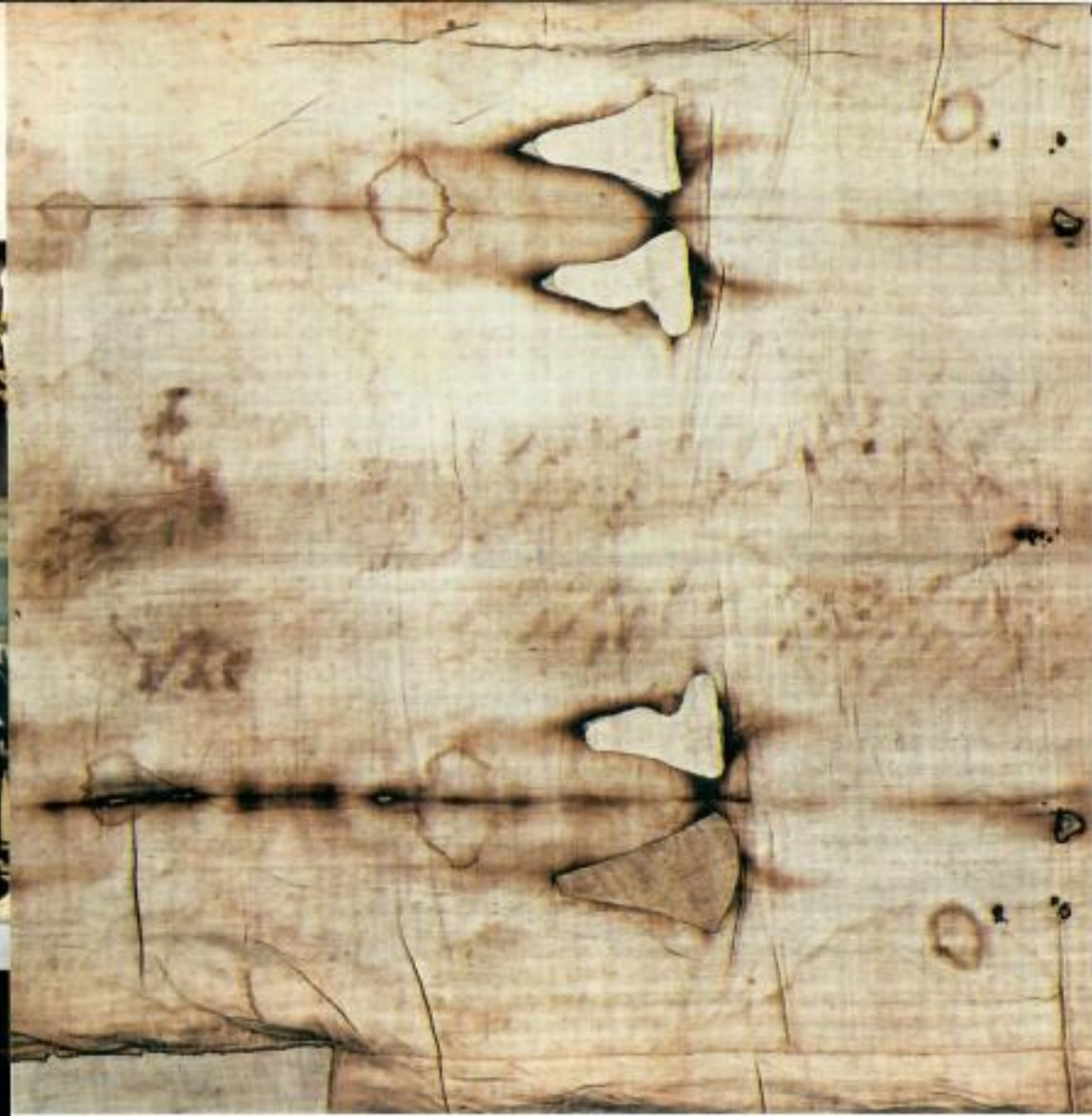
Narrow side strip attached at unknown date

SCOURGE MARKS

Burns made prior to 1532

Size of shroud

BACK IMAGE



14 feet 3 inches
by 3 feet 7 inches

BLOOD FROM
SIDE WOUND
RUNNING TO
THE BACK

SHOULDER
ABRASIONS

BLOOD FROM
PUNCTURE MARKS
ON THE HEAD

Water stains
from putting
out 1532 fire

SWELLING FROM
BLOWS TO FACE

Crease in shroud

LARGE FLOW
OF BLOOD AND
FLUID FROM SIDE

BLOOD FROM
WRIST WOUND
DOWN ARM

BLOOD FROM
NAIL WOUND
IN THE WRIST

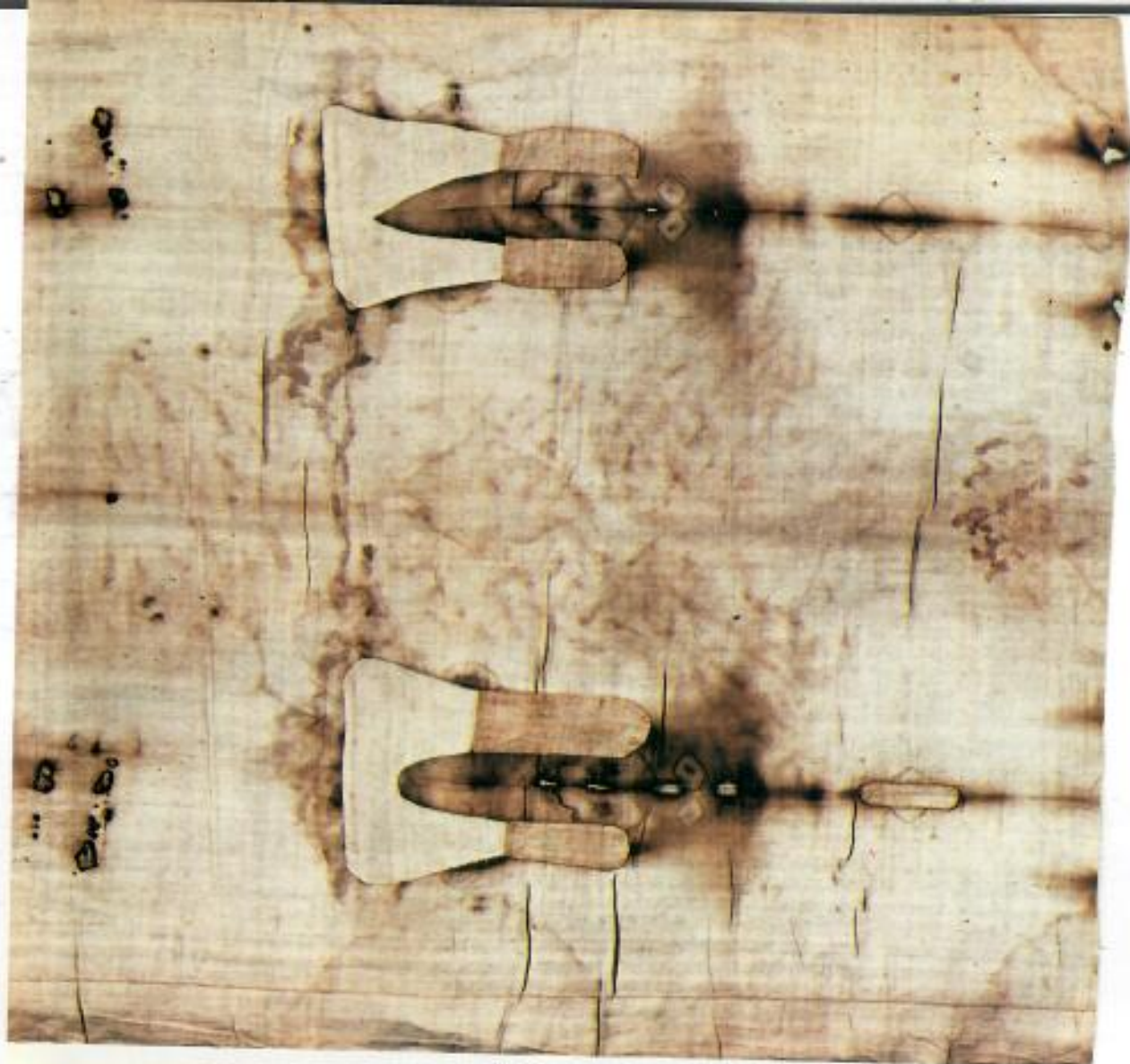
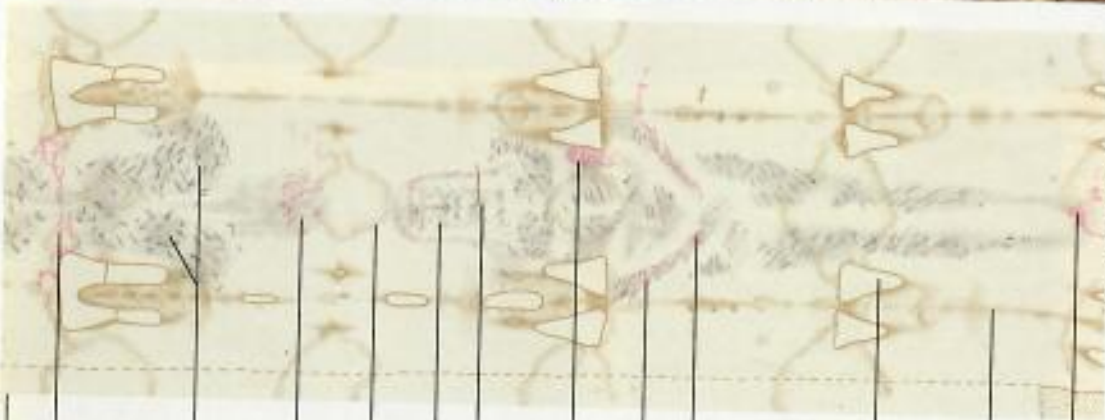
The 1532 fire
burned an edge of
the folded shroud,
resulting holes
patched in 1534

Scorch along
folds from
1532 fire

BLOOD FROM
NAIL WOUNDS
IN THE FEET

FRONT IMAGE
Image of body on
one side of shroud only

DRAWN BY SUZANNE SANDERSON
COLLECTED BY THE
NATIONAL FORENSIC ART DIVISION





Rare glimpse under the shroud allowed Giovanni Riggi of Turin, director of this experiment, Samuel Pellicori of the American team, and Luigi Gonella, a scientist representing the archbishop, to examine "blood" penetration (above).

Narrowing the focus to millimeters with a photomicroscope, team member Mark Evans (right) produced the first photomicrographs of the shroud (far right) for close study of burns, "blood," and body image. Rust was probably left by a tack used in the 1931 exposition.

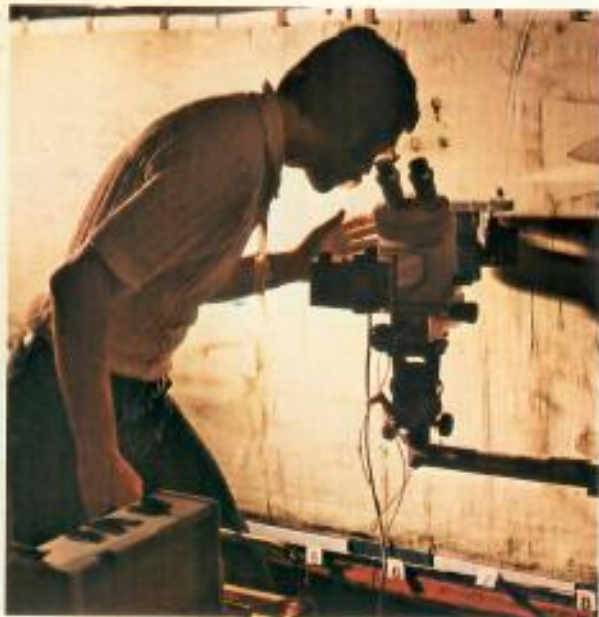
Whereas "blood" spread through the threads and was trapped in the crevices, the yellow stain of the body image is found only on the top fibrils of thread

segments. Had the image been forged using a hot statue, as some have suggested, high spots like the nose would show deeper scorches. Each stained fibril is an identical shade; the darker areas reflect only a greater number of stained fibrils. There is no evidence that color entered the fibrils as a gas or liquid, and there is no trace of pigment buildup.

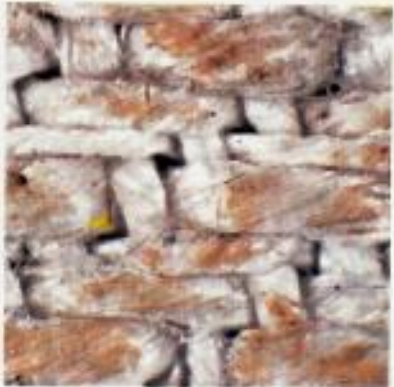
Some of the scientists speculate there was nearly complete contact between a body and the cloth, and that sweat and body oil produced the image over an unknown period of time. Others feel there is stronger evidence that the image is faint scorch, but how it could be produced has not been determined.



© 1980 (ABOVE) AND 1978 (BELOW) BARRIE M. SCHWORTZ; © 1980 MARK EVANS (RIGHT, ALL)



"BLOOD" IMAGE, LOWER BACK 32X



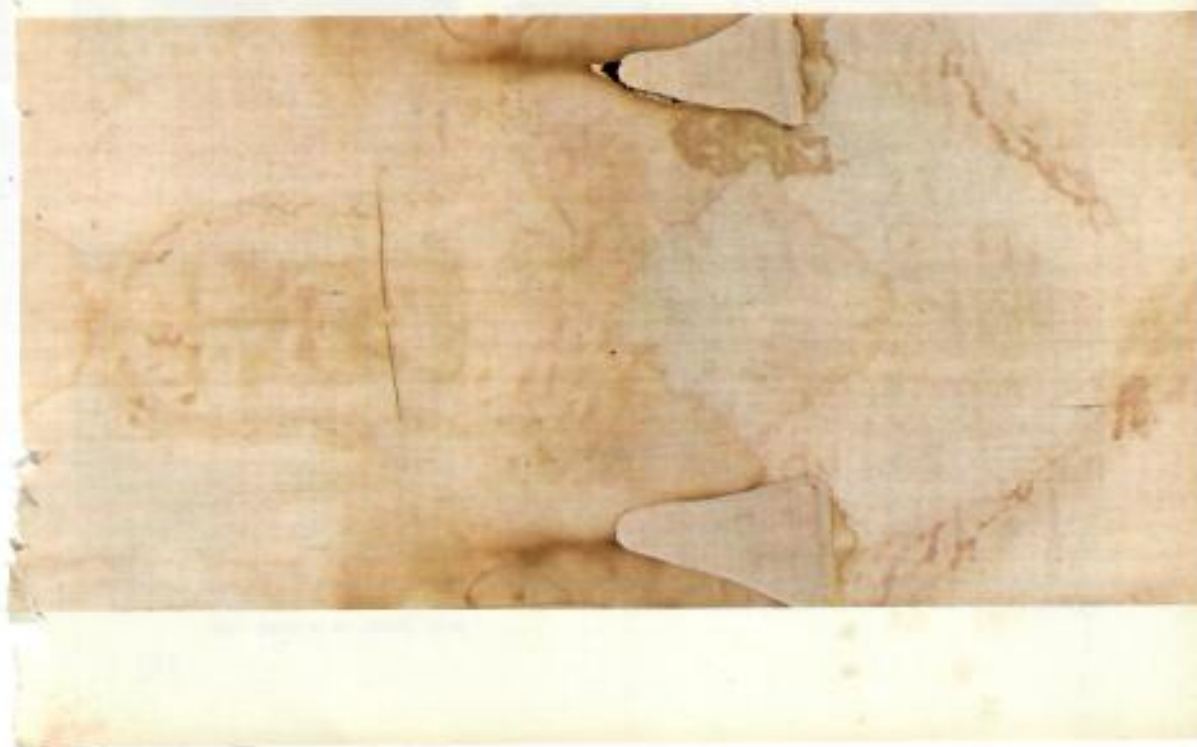
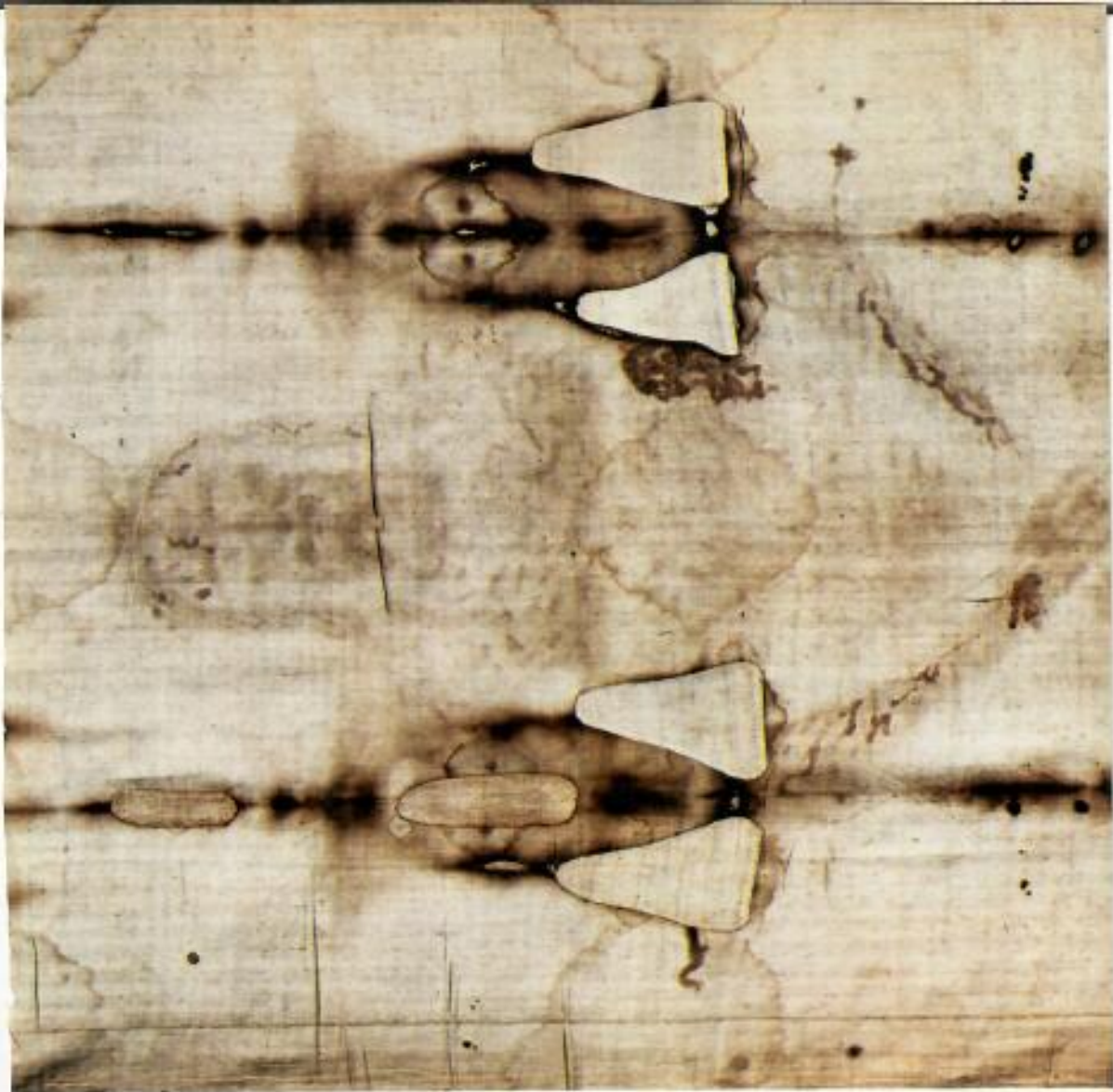
RUST LEFT BY OLD TACK 32X



BURN MARK PREDATING 1832 40X



BODY IMAGE, TIP OF NOSE 40X

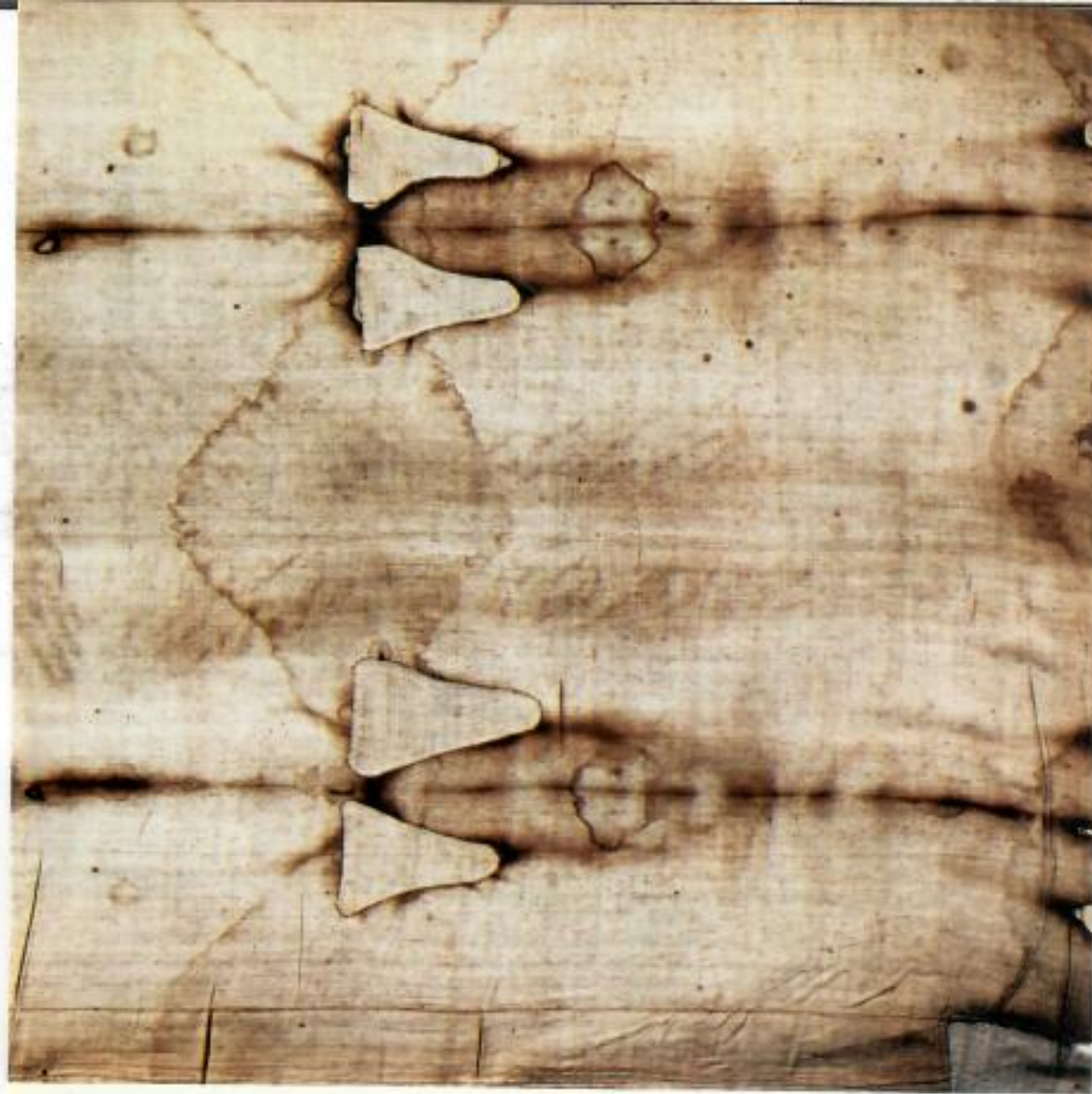


BOTH BY VERNON MILLER; PHOTOGRAPHICALLY ENHANCED BY BILL A. STROCK;
MATERIAL: GEOGRAPHIC STAFF (RIGHT)

flagrum, a multi-thonged Roman whip tipped with lead or bone. Significantly, a nail wound is on the wrist. When a French physician used cadavers to reconstruct the shroud wounds in the 1930s, he discovered that bones in the hand cannot sustain hanging body weight. A medieval forger, shroud scholars reason, would follow artistic tradition and center the nail wound in the palm. Although the Gospels specify hand wounds, "hand" is translated from the Greek word *cheir*, which can also indicate the wrist and forearm.

Mirror-image burns and water marks date from a 1532 church fire when molten silver from the shroud's storage case fell on corners of the folded cloth. Triangular patches and a linen backing cloth repaired the worst damage. The origin of circular burns, which predate the major fire, is unknown.

Woven in a herringbone twill, the shroud measures 14 feet 3 inches by 3 feet 7 inches. The narrow strip sewn to the left edge is of essentially identical weave. Research indicates that the apparently hand-spun fibers and the weave of the cloth are compatible with ancient Middle Eastern textile technology. If radiocarbon tests are allowed, they would date the shroud to within 150 years of origin. A dating near the first century A.D. would not rule out a forgery on ancient linen, but science is as yet unable to determine how such a forgery could have been made.



(Continued from page 734) a two-day international congress on the theme "The Shroud and Science."

I had long been interested in art forgeries and the amazingly clever ways in which scientists detect them. This interest led me to Turin to attend the congress and to get a rare firsthand look at perhaps the most important relic in all Christendom. To Turin came also a team of three dozen Americans, bringing 72 crates of sophisticated instruments and electronic gear with which they hoped to crack the secrets of the shroud.

Floodlights blazed as I entered the Renaissance Cathedral of San Giovanni Battista. High above the altar, behind bulletproof glass, the old-ivory linen—more than 14 feet long—glowed so brilliantly that at first I could see no markings. But as I climbed a ramp and turned into a raised walkway in front of the "Santa Sindone," I began to discern the image that has stirred such imagination and devotion—and controversy—over the centuries.

The twin lines of scars and the water stains from the 1532 fire dominated. The image itself—mistlike sepia impressions—seemed to fade into the cloth as I moved in closer. It was necessary to back off for the eye to resolve details.

The "blood" showed darker than the body and stood out more sharply: trickles on the head and arms; splotches on the side, wrist, and feet; and multitudes of what appeared to be lash marks. At the ends of the lash marks seemed to be contusions of a type that could have been inflicted by a Roman whip called the *flagrum*, whose thongs were tipped with bits of lead or bone. Clearly, the figure on the shroud had suffered savage and humiliating treatment.

I could not guess, from my vantage point, whether the linen was ancient or merely old; how the image had been imprinted; whether the "blood" was really blood; whether the shroud was genuine or a hoax. These were the questions the scientists had come to address.

It would not be the shroud's first brush with science. That happened eighty years before, in 1898, with the first photographs of the relic. Those pictures uncovered the most

surprising of the shroud's many mysteries.

When the photographer, Secondo Pia, examined his first glass-plate negative as it emerged from the developing bath, he almost dropped it in shocked excitement. He was looking not at the usually unrealistic, confusing photographic negative, but at a clear *positive* image. Highlights and shadows were reversed from those on the cloth and were far more lifelike and realistic. Moreover, they showed details never before seen in the shroud, which was now revealed as a *negative* image.

A negative image? Hundreds of years before the invention of photography? The idea that the shroud was a hoax suddenly seemed less plausible, for how could a medieval artist have produced a negative image, and why would he choose to do so?

Turin's treasure was now the object of much interest, and also of heightened controversy. Just at this time it came under attack from a distinguished cleric and historian, Ulysse Chevalier, said to be "the most learned man in France and perhaps in the entire world." After a study of some fifty records concerning the shroud, Chevalier threw the full weight of his reputation against it; he pronounced it false.

Biologist Propounds Vapor Theory

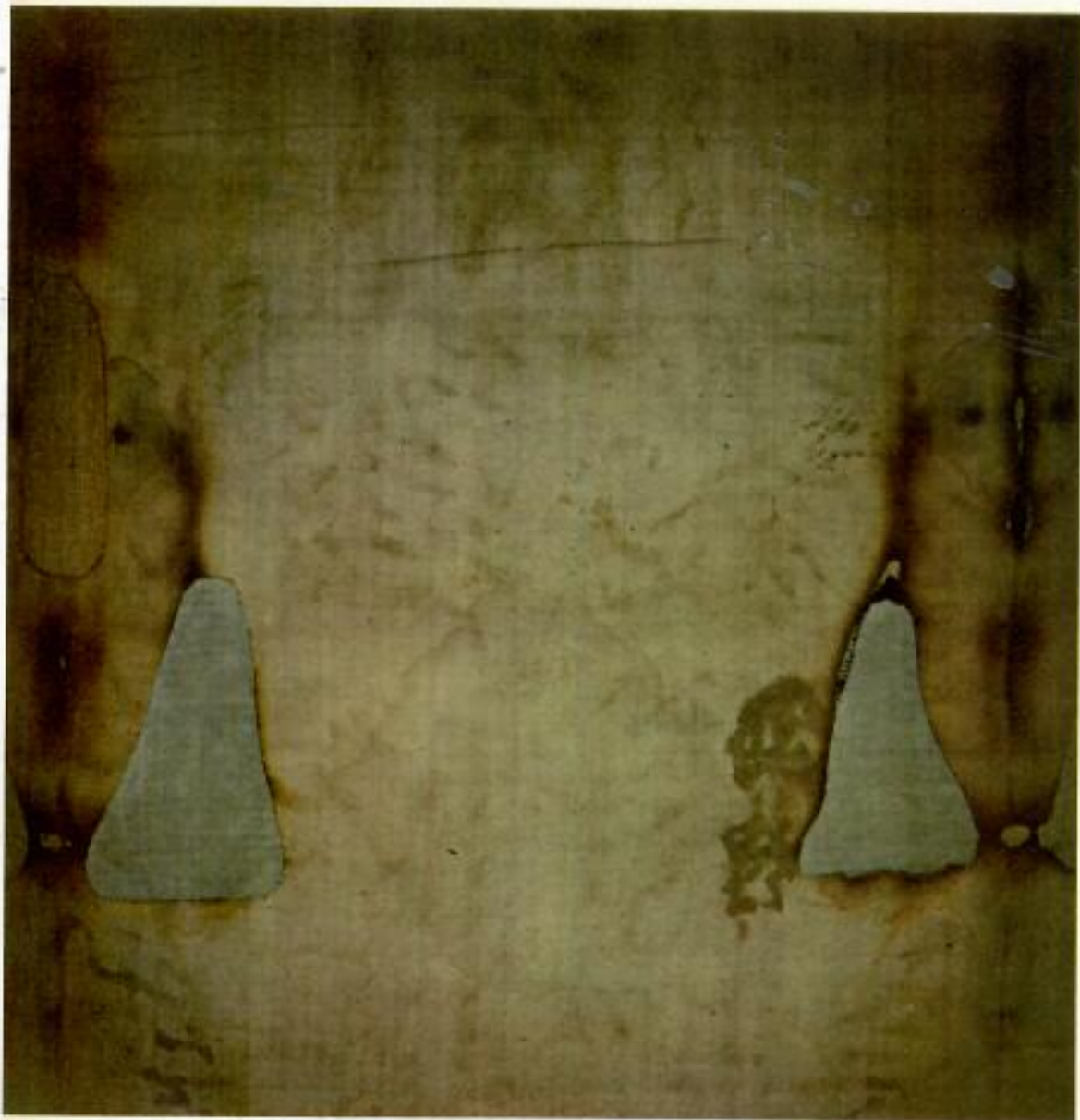
Ironically, it was a scientist—and an agnostic to boot—who came to the shroud's defense. He was the internationally noted zoologist Yves Delage. With a young biologist assistant named Paul Joseph Vignon, he had carefully studied Pia's photographs and pondered how the image had been produced. Could it have been painted? He and Vignon tried to duplicate it with oils; they tried watercolors. Nothing worked.

Then Vignon pursued another approach. He theorized that myrrh and aloes—spices used with oil in ancient burial rites—might sensitize burial garments. He knew that morbid sweat from a tortured body produces urea, which in time gives off ammonia vapor. This vapor, he reasoned, would cause the impregnated cloth to turn brown.

He tried an experiment and produced an image of sorts. The "vaporograph" theory was born, and the two men were sure they knew how the image had been formed.

In 1902 Delage went before the French

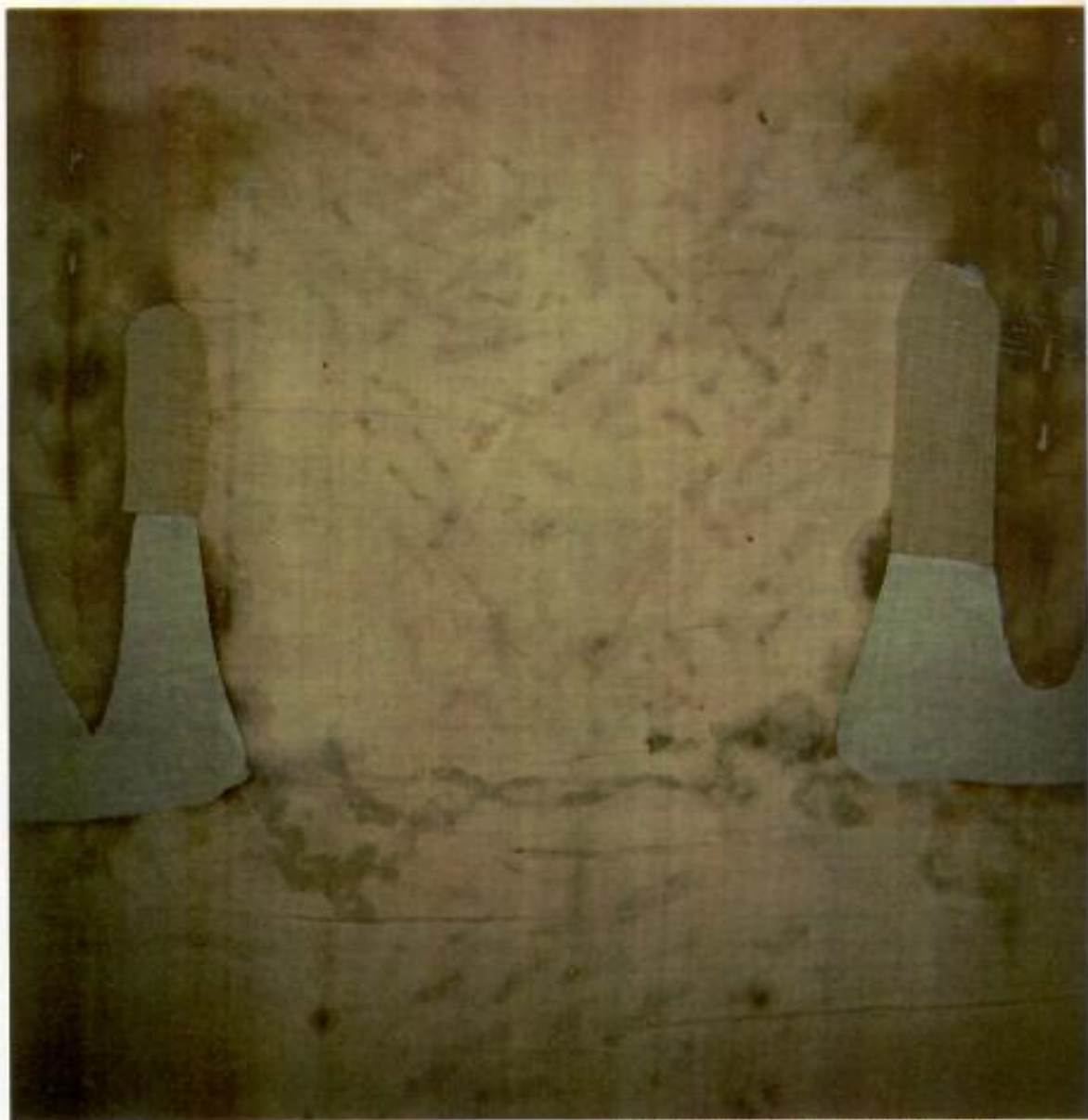




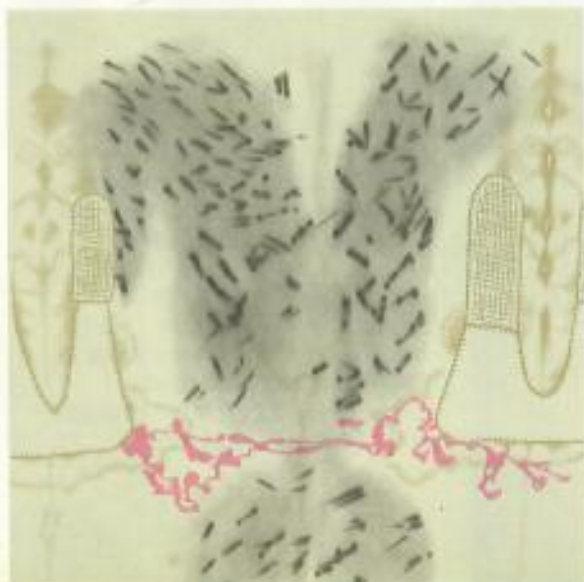
NATIONAL GEOGRAPHIC ART DIVISION (BELOW AND RIGHT)

Pale aura around the side wound is enhanced in an ultraviolet fluorescence photograph (above and diagram). Some team members think it may be serum, which separates from blood at death. Fluorescence is a clue to chemical makeup. Electrons excited by radiation give off energy, but not all compounds emit this energy by fluorescing. Whole blood does not fluoresce, so it is notable that neither scourge marks nor "blood" images show fluorescence.





© 1990 VERNON MILLER, BROOKS INSTITUTE (LEFT AND ABOVE)



Shroud scholars think it unlikely that a forger would anticipate the flow of "blood" across the back (**above and diagram**), which might have spread from a side wound when a body was moved.

In these photographic tests the scorches from the 1532 fire show reddish fluorescence, while the body image does not. Some project members believe this casts doubt on the scorch theory. Yet in other tests the body image and fire scorches react similarly.

Apparent absence of thumbs on the hands (left) may be related to nail penetration through the wrists. Such piercing might stimulate the median



© 1980 VERNON MILLER, BROOKS INSTITUTE (BOTH)

NATIONAL GEOGRAPHIC ART DIVISION



nerve and cause an involuntary contraction of the thumbs.

*Auras around "blood" on the wrist and one foot (detailed in **diagrams**) are also thought by some to be signs of serum. Watery serum is squeezed out of clotting blood.*

Fine diagonal scratches, found with scourge marks, are revealed in these ultraviolet fluorescence photographs. They appear strongest on the back of the legs (left).

Academy of Sciences and presented details of the experiment. At enormous risk to his reputation, he pronounced: "The man of the shroud was Christ."

The academy was outraged and refused to print his statement. Controversy became more intense.

Some thirty years later a noted French surgeon, Dr. Pierre Barbet, saw the shroud and became interested in a new set of photographs made in 1931 by Giuseppe Enrie. Barbet sought to verify the anatomical accuracy of the marks on the shroud by experimenting with cadavers. He quickly learned that nails in the palms will not support a man's body. On the other hand, a nail in the wrist or forearm will not tear out.

This knowledge made the case for the shroud's authenticity seem stronger. For the mark of the nail on the shroud image is *not* in the palm (as it is traditionally seen in paintings of the Crucifixion) but in the wrist area. A medieval hoaxer would presumably have based his image on what he had seen in paintings and on the fact that the Gospels speak of nail holes in the hands. He would not likely have known that the Greek word for hand, *cheir*, can include wrist and forearm as well.

Although the Romans put many thousands of victims to the cross (6,000 after the revolt of the slave Spartacus), no skeletal remains were known until the unearthing of a cemetery in Jerusalem in 1968.

In one ossuary archaeologists found the bones of a man named Jehohanan. The lower legs had been broken, as was the crucifixion custom, and a spike still lodged in the heel bones with a bit of olive wood from the cross clinging to it. But most remarkable: The nail driven into the right arm had left a clearly defined scratch and worn place on the inside of the radius, close to the wrist. Archaeology had confirmed the medical evidence that the shroud's image is correct.

Until this time the shroud had been studied almost entirely from photographs. But in 1969 and again in 1973, experts—chiefly Italian—were allowed to examine the shroud itself. The first group made only a cursory inspection and came up with no new knowledge. But the 1973 group made several startling discoveries.

For one thing, they learned that the image

is completely superficial; it lies on the very topmost fibrils of the threads, and has not penetrated at all. Moreover, they reported that no pigment could be seen, even under magnification.

Detective Finds Pollen From Palestine

Another discovery seemed to place the shroud in the Holy Land at some time in the past. A Swiss criminologist, Max Frei, was permitted to press sticky tape on the shroud to remove dust and other particles for laboratory analysis (page 750). Under his microscope Frei found 48 samples of pollen—tiny male reproductive bodies, produced by seed-bearing plants, that survive for centuries even in hostile conditions.

Pollen grains vary—some are fuzzy, some spiny, some grooved—and no two species are exactly alike. Thus many plants can be identified with high accuracy by comparing pollen to a standard reference collection.

Among his identified samples, Frei found a number from plants that are found in France and Italy, as would be expected. In addition there were seven from halophytic (salt-loving) plants found in saline areas such as the Dead Sea, and others from Palestine and Anatolia.

On the face of it, Frei's findings suggested that the shroud had been in the Holy Land at some time in its history. Not all scientists, however, are ready to accept this evidence uncritically. They note that pollen is borne great distances by the winds and by birds and travelers, and the shroud is known to have been exhibited out of doors, without protection, on occasion over the centuries.

A further set of findings was based on two small fragments and a number of threads snipped from the shroud in 1973 and turned over to an internationally known textile expert, Professor Gilbert Raes of the University of Ghent, Belgium.

Some of the textile indications seem to point to the Holy Land and to great antiquity. The material is linen, commonly used in ancient Palestine for graveclothes. Raes found that it has traces of cotton of a Middle East variety.

The weave is a herringbone twill, a pattern not unknown to the ancients, although plain weave was much more common in those days. The thread appears to be hand

spun, an ancient technique; after about A. D. 1200, European thread was spun by the wheel. Finally, the threads are believed to have been bleached before weaving, also an ancient practice.

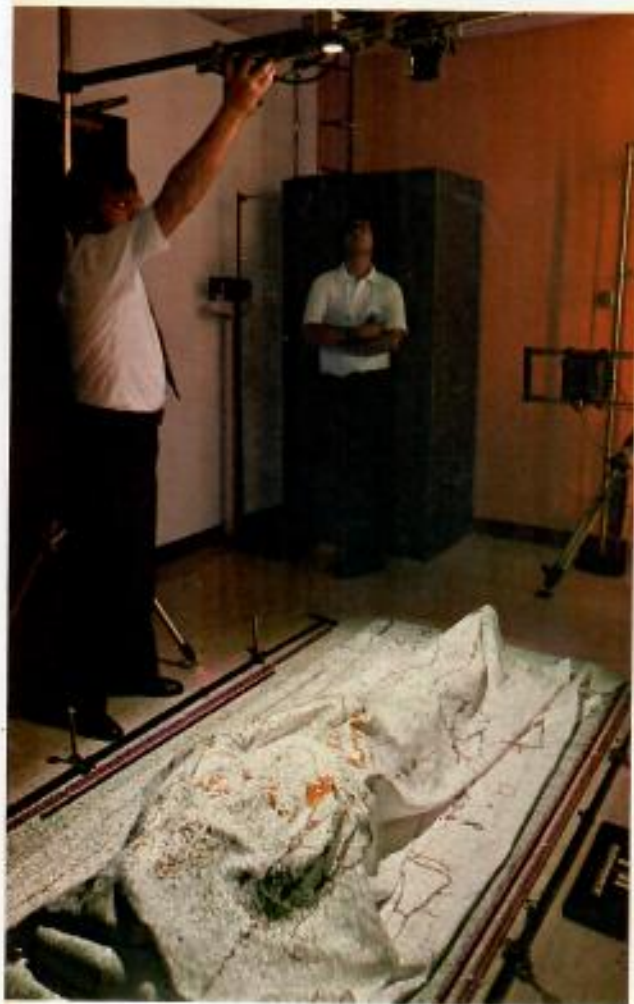
A Readout in Three Dimensions

The current scientific interest in the shroud in the United States began with two young Air Force scientists, John Jackson and Eric Jumper. As long ago as 1974 they had begun an intensive study of the Enrie photographs. Like Vignon, they observed that the darkness, or intensity, of each part of the image varies in direct proportion to how far that part of the body would have

been from a covering sheet. The darkest portions would have been closest to the sheet, and the lightest farthest away.

They concluded that whatever had created the image could have acted at a distance, not just by direct contact.

To demonstrate their idea, they processed the pictures with the VP-8 Image Analyzer, a sophisticated instrument designed to convert image intensity to vertical relief. To their surprise they found that the shroud contains accurate three-dimensional data, something that ordinary photographs or paintings do not have. With the computer information they were able to construct a three-dimensional model of the image.



To map a shroud-covered body, stereometric photography charts contours. A man matching the height (approximately 5 feet 11 inches) and build of the image is photographed under a shroud replica (above left), and then uncovered (above center). Contours are compared to measure cloth-to-body distances. Experiments

This work attracted the attention of other scientists, highly qualified in their fields. In March 1977 a group of them met in Albuquerque, New Mexico, with a number of shroud scholars from Europe. That meeting set in motion a plan to test the shroud scientifically the following year when it would go on public exhibition in Turin.

Working through Father Peter Rinaldi, a native of Italy who had for years served a parish in the United States before returning to Turin, and Father Adam J. Otterbein, long a leader in the American shroud movement, they sought official permission. Umberto II, former King of Italy and the shroud's legal owner as head of the House of

Savoy, had for years favored testing. From his home in exile in Portugal he gave approval. Turin's Archbishop Anastasio Ballestrero, to whom the relic is entrusted for safekeeping, also approved. He gave scientists a free hand for any nondestructive tests.

And so the Shroud of Turin Research Project came into being. The team began detailed preparations to build and collect specialized instruments and work out a schedule for their tests.

On Sunday night, October 8, 1978, the Turin exposition ended. As the last pilgrim left the cathedral, the shroud was carefully taken from its nitrogen-filled case and moved to the adjoining Royal Palace.



ALL BY NATIONAL GEOGRAPHIC PHOTOGRAPHER VICTOR R. BOSWELL, JR.

show that intensity of the shroud body image varies in proportion to the distance between cloth and body. Scientists John Jackson and Eric Jumper (*above*, left and right foreground) also dressed models with chin bindings, forehead phylacteries, and coins on the eyes, images of which some believe they see on the shroud.

There, in the handsome gilt-and-crystal hall once used to receive visiting royalty, it would remain for five days. The scientists—including Italian groups and a Swiss expert as well as the Americans—would work around the clock making their tests.

A long tilting table had been built on which the linen could be held by magnets and clamps. As the shroud was smoothed out, the scientists noted that the fabric was well preserved and surprisingly supple—though yellowed with age, creased, and showing evidence of much folding.

Perhaps never before had an object of art or archaeology been subjected to such exhaustive examination. The scientists bombarded the relic with ultraviolet radiation and X rays and watched for fluorescence. They measured variations in the way the image, the "blood," and the background emitted or reflected energy across a wide range of the electromagnetic spectrum. In infrared, visible light, ultraviolet, and X ray, they searched for "fingerprints" of the shroud's chemical makeup.

X-ray fluorescence, for example, can

detect iron and potassium in blood, or spot heavy metals usually found in paints.

Other specialists photographed every square inch of the linen in detail—some 500 exposures using various wavelengths. They examined it microscopically and took photomicrographs (page 742). With sticky tape and a vacuum device they captured bits of fiber, dust, pollen, and other particles for analysis. They loosened the backing cloth (stitched on by 16th-century nuns) to see what is on the back of the shroud. Biologist Giovanni Riggi of Turin photographed the back surface with the use of fiber optics and collected micro-particles. Several additional threads were taken.

Investigators Begin Analyzing Data

Elated but exhausted, the team finished its work on Friday night. The shroud was rolled in red silk, replaced in its silver-bound reliquary, and returned to the ornate chapel where it has rested for centuries. High above the marble altar, it remains behind a glass window and iron bars.

Back home in their laboratories with their



© 1980 BARRIE N. SCHWARTZ

Microscopic clues cling to tape applied to the shroud by Swiss criminologist Max Frei. Samples taken by Frei during a 1973 examination held pollen from plants native to the Palestine area, which some cite as evidence that the shroud was once in the Middle East. But the relic was sometimes displayed unprotected, and far-ranging airborne pollen could have easily collected.

*Chemist Ray Rogers, left, took 36 tape samples for the American team. Researching textile history, Rogers uncovered the ancient practice of washing cloth in detergent made from a soapwort, *Saponaria officinalis*. Experiments show that saponaria-treated linen scorches more easily. *Saponaria* is a known fungicide, which may explain why the shroud has no obvious mold or mildew.*

six tons of equipment, the team members* began the laborious task of processing and analyzing the data, the photographs, and the samples. It was slow work, depending on spare time. Today, more than a year and a half later, much of the work continues amid some disappointments and conflicting evidence, but with an abundance of new information that brings the answers to the riddle ever closer.

What is the nature of the image? Under magnification, the scientists report, the fibrils from the image area show a light yellow coloring that lies only on the very topmost surface of the threads. The coloring has not diffused or soaked into the threads, has not run down the sides of the threads, and has not left deposits between threads as one would expect if pigments had been painted or rubbed on.

Here the fire of 1532 becomes helpful. Some of the scientists say that heat sufficient to char the fabric should have been enough to alter the color of organic pigments or vehicles, and the color change should be greatest close to the burned area. Yet the yellow coloring on the shroud image is remarkably uniform right up to the edge of the burns; it has not been altered. Moreover, water thrown on the shroud to put out the fire would have caused inks to run. Clearly that did not happen.

In light of these facts, the scientists as a group have settled on one far-reaching conclusion. Chemist Ray Rogers of the Los Alamos National Scientific Laboratory sums it up: "Nearly all of us now believe that the shroud is not a painting. Except for a small amount of iron oxide, we find no pigment. And we do not think that either liquid or vapor could have produced the image we see."

One team member, microscopist Walter C. McCrone of Chicago, has developed a hypothesis based on microscopically visible amounts of red iron oxide he sees clinging to many of the yellow fibrils. He describes this finely divided material as similar to artists' iron-rich earth pigments, such as red ocher. He proposes the idea that this material was used at some time to enhance the image. This hypothesis is regarded as doubtful by many of the other scientists.

One other team member—spectroscopist Samuel Pellicori of the Santa Barbara

Research Center—proposes still another hypothesis: The image, he suggests, was formed by the darkening over the course of time of body oils, sweat, or spices such as myrrh. It is, in that case, an image formed by contact. Spectroscopic evidence seems to support his idea, but—as other team members point out—such an image would have no three-dimensional qualities. Moreover, the image shows details in the face where a cloth would not have touched.

Likely Explanation Inexplicable

What, then, is left to explain the image? On this point the findings from various instruments suggest that the image is like faint scorch. Indeed, the image shows up in the tests in much the same way as the lightly burned portions of the areas damaged in the 16th-century fire.

Unlike pigments, scorch would have gone through that fire without changing color. Also, scorch could have been subjected to water without fading or running.

What scorching mechanism could have produced the delicate image we see on the shroud is still undetermined.

One curious sidelight of the scorch hypothesis emerges from the research of Ray Rogers and an associate, Diane Soran. Combing books for leads, they found a reference by the Roman historian Pliny to the use of a substance called *struthion* for washing and softening fabrics. *Struthion* was the classical name for a soapwort, *Saponaria*

*Investigators for the Shroud of Turin Research Project (STURP) include Joseph S. Accetta, Lockheed Corp.; Steven Baumgart, John D. German, U. S. Air Force Weapons Lab; Ernest H. Brooks II, Mark Evans, Vernon D. Miller, Brooks Institute; Robert Bucklin, Harris County (Texas) Medical Examiner's Office; Donald Devan, Oceanographic Services, Inc.; Rudolph J. Dichtl, University of Colorado; Robert Dinegar, Donald and Joan Janney, J. Ronald London, Roger A. Morris, Ray Rogers, Larry Schwalbe, Diane Soran, Los Alamos National Scientific Laboratory; Thomas F. D'Muhala, Nuclear Technology Corporation; Joseph Gambescia, St. Agnes Medical Center, Philadelphia; Roger and Marty Gilbert, Oriol Corporation; Thomas Haverty, Rocky Mountain Thermograph; John Heller, New England Institute; John P. Jackson, Eric J. Jumper, U. S. Air Force Academy; Jean Lorre, Donald J. Lynn, Jet Propulsion Laboratory; Walter C. McCrone, Walter C. McCrone Associates, Inc.; Robert W. Mottern, Sandia Laboratories; Samuel Pellicori, Santa Barbara Research Center; Giovanni Riggi, Società Progettazione Riggi; Barrie M. Schwartz, Barrie M. Schwartz Photography.

officinalis. Some of the sources indicate that weavers used starch to coat warp threads to stiffen them and then washed out the fabric with saponaria when it was completed.

Diane Soran procured linen samples similar to the shroud material, washed some in saponaria and some without, and then briefly applied heat. The saponaria-treated swatches scorched much more rapidly and deeply than the untreated samples. Thus, if the shroud had ever been washed with saponaria, it would have been rendered quite susceptible to scorching.

Saponaria proves of interest in another way. It is toxic to lower forms of life and is a fungicide. That, perhaps, could explain why the shroud shows no obvious mold or mildew despite having been kept for long periods in damp and musty churches.

Questions Many, Answers Few

Is the "blood" really blood? It has long been clear that the "blood" stains and the image are quite different. Secondo Pia discovered this fact when he looked at his negative plates. The "blood" areas showed white on the negative, proving that those stains on the shroud are positive, while the body image, as we have seen, is negative.

The scientific team at Turin found another significant difference between the "blood" and the image. When they loosened the backing cloth, they saw that a viscous liquid in the "blood" areas had penetrated all the way through the linen. Yet the body image is invisible from the back. Obviously the two areas were produced in some completely different way.

No test so far decrees that the "blood" is not blood. On the other hand, a number of tests suggest that it could be. The stains under X-ray and ultraviolet radiation respond very much as does blood. In addition, the X-ray tests show the correct percentage of iron for blood.

Finally, Dr. John Heller of the New England Institute has found in the debris on the tapes a tiny crystal that he considers to be a form of hemoglobin much altered by age. He believes the crystal is blood. Other team members are divided on the question and await further tests.

How old is the shroud? This most obvious question of all has not been touched. Radiocarbon dating would determine the age of the fabric, but it has not so far been permitted. Some material has to be destroyed in radiocarbon testing, and the authorities have feared it would require too much of the shroud.

A new technique, however, now meets that objection. It is a fast, highly accurate method involving an accelerator used as a mass spectrometer, and it requires only a smidgen of material.

Dr. Harry Gove of the University of Rochester says that with one square centimeter (the size of the tip of your little finger) he can provide an age conservatively accurate within 150 years. Even after purifying the material and ridding it of all contamination, enough carbon would be left to repeat the test several times.

Indications from Turin now lead to the belief that Turin's archbishop will eventually give permission for carbon dating.

Even if all tests should say that the shroud is truly ancient, that it dates from the first century A.D., mysteries would still intrigue us. How is the three-dimension information encoded in the image? If the image is scorch, how was it produced? Have the scientists considered all the techniques by which a forger could have done the work? Could a vehicle for an iron oxide pigment have aged and caused the yellow fibrils?

Above all would remain the question: *Is it the shroud of Christ Himself?* That, say both scientists and theologians, will remain forever outside the bounds of proof. □

A positive image on a photographic negative? Light and dark areas now appear where the eye expects them, and the man of the shroud becomes astonishingly lifelike. When the first photograph of the shroud revealed this phenomenon in 1898, it triggered an interest that has not abated. But the genesis of the image remains unknown. As more questions are answered, more arise.

© 1980 VERNON HILLER, BROOKS INSTITUTE

