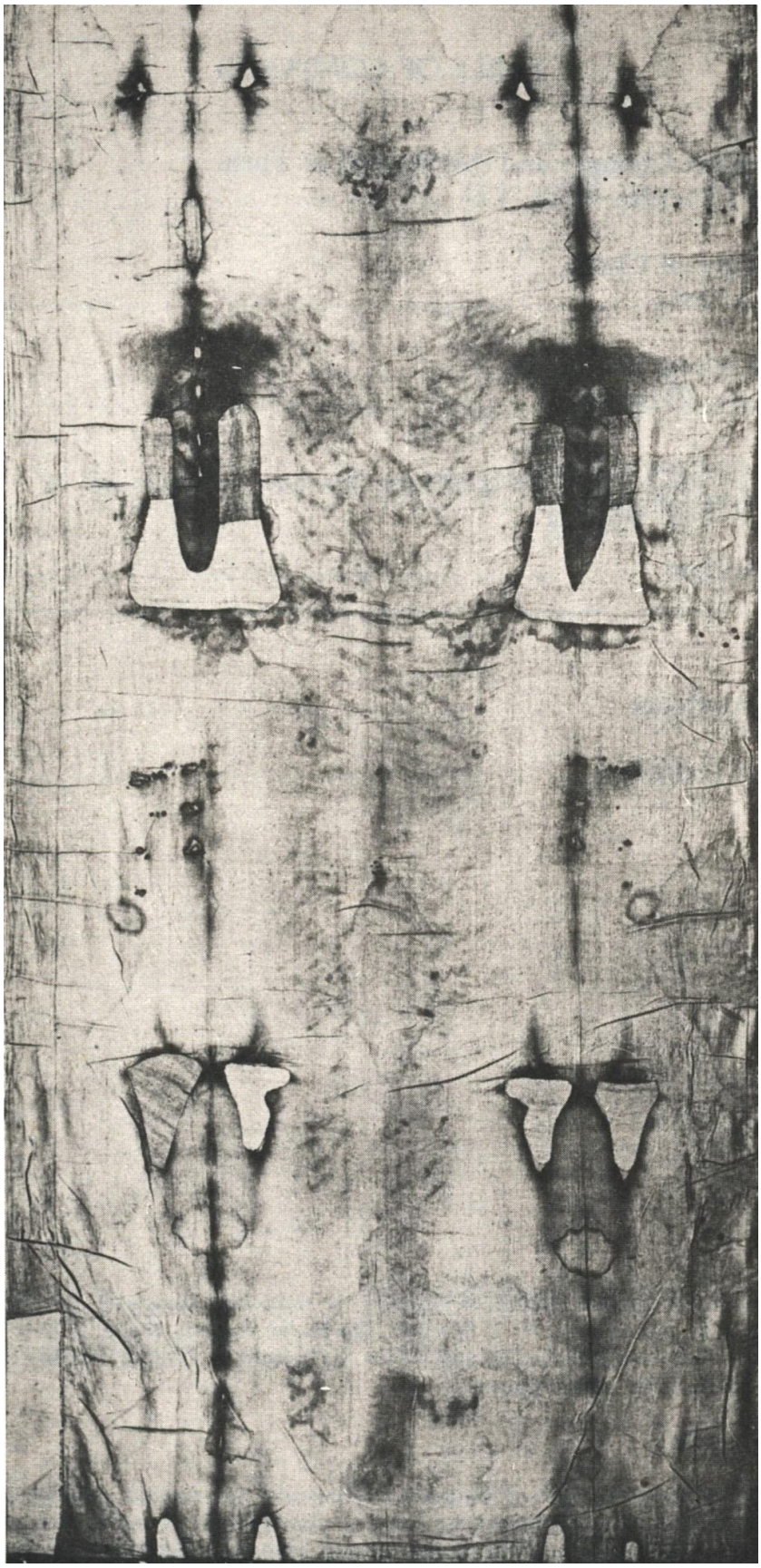

The dorsal image, showing signs of Rigor Mortis.

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POSTMORTEM CHANGES AND THE SHROUD OF TURIN

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The Shroud of Turin has been subjected to intensive scientific investigation and research over the years in order to determine as much as possible about the nature of the image on the cloth and the various stains that appear in both image and non-image areas.

Among the exhaustive tests done are those which seek to study the medical aspects of the injuries suffered by the man whose image appears on the Shroud. In an attempt to correlate the antemortem and postmortem injuries with the manner of death by crucifixion, the question of the presence of postmortem changes, including cellular decomposition and rigor mortis, has been considered.

It is the aim of this paper to compare the interpretation of the actual changes apparent on the Shroud image with known medical standards of postmortem changes, including rigor mortis and bodily decomposition.

At the moment of death, an initially intact body commences to decompose unless intervening circumstances prevail. The earliest changes of decomposition take place at the cellular level and are thus not immediately visible. The process continues with the progressive breakdown of soft tissues and chemical alteration of their anatomical constituents, such as protein, carbohydrates and fat. Decomposition is due essentially to the action of many enzymes: some are present in the body before death and others derive from chemical reactions that occur postmortem as substances normally confined within cells, as hemoglobin, potassium and enzymes. These are released upon cellular death. At the time of death, bacterial organisms in the intestinal and respiratory systems migrate from their usual locations and invade body tissues, locally and systemically. The result of chemical and physical alteration of tissues is accompanied with overgrowth of the bacteria, and the process is defined as decomposition. Fat breakdown starts within minutes of death. Protein of nerve tissue and epithelium is among the earliest to degenerate. Body organs that have higher concentrations of proteolytic enzymes, as intestine, pancreas, kidneys and liver, are first affected. Connective tissue, cartilage and bone are affected more slowly. Tissues of the skin maintain integrity longer than most internal organs.

Postmortem changes do not proceed in a uniform rate for all body organs and there is a recognizable individual variation from one person to another in the rate of postmortem change. Likewise, extrinsic

factors can affect the progress of decomposition. For example, body cooling after death slows the chemical reaction. The size and weight of the body also affects the rate of decomposition, with a smaller body expected to decompose more slowly than a large one because of the greater loss of heat from the smaller body. The environmental situation of the dead body is important in establishing the rate of decomposition, and it is to be expected that a moist warm environment will enhance postmortem tissue changes. Premortem bleeding may reduce the temperature of the body and therefore slow decomposition. Use of antibiotics before death may retard bacterial growth and have an effect on the rate of cellular breakdown. Similarly, any process which increases the body temperature, such as infection or sepsis with bacterial growth, will enhance decomposition.

The first observable changes in the body include clouding of the cornea of the eyes and subtle changes in the skin, such as discoloration. It is only after a number of hours that significant changes may occur in the skin in the form of bleb formation, slippage or actual breakdown with sloughing of the skin. Temperature loss after death occurs in a predictable rate to the point that postmortem temperature can be used as an indication of the time of death with reasonable accuracy. The development of rigor mortis or body stiffening after death is also a predictable event.

Rigor mortis is an early and obvious postmortem change manifested by a stiffening of all the body muscles, both voluntary and involuntary, as well as large and small. Rigor ordinarily starts about 4-6 hours after death and continues for about 12 hours, at which time it is complete. Rigor gradually diminishes over the following 12-24 hours. Its first manifestation is in the small muscles of the fingers, toes and face. As it develops, it becomes apparent in larger muscles throughout the body. As rigor leaves, it does so in the same order, beginning with small muscles. If, for some reason, a muscle in rigor is manipulated, the rigor will be broken and will not return.

Rigor mortis development and release is an intricate chemical process, dependent on interaction of several enzymes. In the human body, adenotriphosphate (ATP) is of prime importance. The enzyme adenotriphosphatase acts upon ATP to produce adenosine diphosphate (ADP) and phosphate, together with a large amount of energy for cellular activities. In muscle cells, this energy is utilized for contraction and relaxation. As ATP is exhausted, it is resynthesized by the body from ADP combined with other substances including phosphocreatine and glycogen. As long as the supply of ATP is sufficient, the muscle cells remain relaxed and elastic, and when the ATP supply is reduced to a critical level, muscle contraction occurs.

At the point of death, there is usually sufficient ATP to maintain muscular relaxation, but during decomposition of the cells ATP is progressively and irreversibly destroyed. Since resynthesis is not possible after death, no new ATP can be formed and when the ATP

level falls to the critical level, the muscle will contract and produce the condition known as rigor mortis. Extrinsic factors may influence the development of rigor mortis. For example, if the amount of ATP in the system has been depleted just prior to death, due to increased muscular activity on the part of the individual, rigor mortis may appear almost immediately after death. Occasionally, certain muscles may attain a seemingly premature stiffening before generalized rigor mortis appears, due to a contraction of particular muscles prior to death because of depletion of available ATP. The condition is called cadaveric spasm. Heat will hasten ATP breakdown.

Relaxation of rigor mortis signals the onset of postmortem decomposition of muscle protein by enzymatic action. Rigor mortis can no longer occur after the decomposition of muscle protein.

With this background, one is able to approach the image on the Shroud of Turin objectively, in search of any features that might suggest postmortem changes, including rigor mortis.

None of the research done on the Shroud image has produced any evidence that there has been cellular changes such as might be expected as the result of a long postmortem interval. It is not unreasonable to expect that, as the result of postmortem decomposition, there might be abnormal compounds on the skin surface of the deceased representing protein breakdown. These could be expected to have been transferred to the cloth by body contact if they were present. To date none has been found. In regard to the Shroud of Turin image formation, it would not be expected that any of the subtle changes in the eyes or skin could be demonstrated.

Upon close observation of the image, one gets the impression that there is a certain degree of stiffness of the body. This is perhaps more apparent to the trained forensic pathologist than to the casual observer and it does represent a subjective element which cannot be equated scientifically. There are, however, some distinct features of the image that strongly support the opinion that rigor mortis is present.

The most important of these features is the position of the lower extremities seen from their posterior or dorsal aspect. It is clear from this view that imprints of the right and left calves are quite different. The right calf has made a near-complete imprint on the fabric of the Shroud, while the left calf is far less clear. Also, the imprint of the left foot, unclear as it is, is somewhat higher than the more distinct imprint of the right foot and especially the right heel. Coupling these leads to the conclusion that the lower legs were not resting parallel and in extension at the time the body was placed in the Shroud. If they had been in such a natural position it would be expected that the calf imprints would be similar and equal in appearance and that the heels would be in the same plane. One of the best reasons for this discrepancy is the likelihood that at the time of death the left leg was drawn up, slightly flexed at the knee, and medially rotated to a position where

the left foot rested upon the right instep. This is a very likely crucifixion position, whereby the right foot rested directly upon the wooden part of the stipes of the cross and the left foot was placed on top of the right instep. The maintenance of this position is definite evidence of the development of rigor mortis.

It will be noticed that the image of the head is in a flexion position with the chin close to the chest and slightly turned toward the right. For this position to be maintained with the body in the burial cloth requires the presence of rigor mortis. If there were no rigor, the head would have become rotated into a more natural anatomic position.

The upper extremities of the Shroud image lie in a position over the lower abdomen and pelvis. Rigor mortis cannot be demonstrated in the arms and forearms on the Shroud image and it can only be concluded that any stiffening that was present was broken as the arms were positioned in the Shroud for burial.

I feel that a word should be said about the medical aspects to a study of this type. It is my very strong opinion that a conservative approach must be taken and that one must not allow himself to be misled in his interpretations. The image on the Shroud most certainly lends itself to scientific study and conclusions, but those conclusions must not be colored by emotions or by an attempt to "read" into the Shroud image something that is not there, on the basis of examination alone. As studies progress and newer techniques of examination of the Shroud image become available, it is very likely that more certain statements may be forthcoming, well within the limits of scientific accuracy.

In summary, this has been a review of the pathophysiology of postmortem changes related to decomposition and rigor mortis with application of those principles to a study of the image on the Shroud of Turin. It is my opinion that no signs of postmortem decomposition appear on the Shroud image and that there appears clear evidence that the body was in a state of rigor mortis when placed in the Shroud.

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