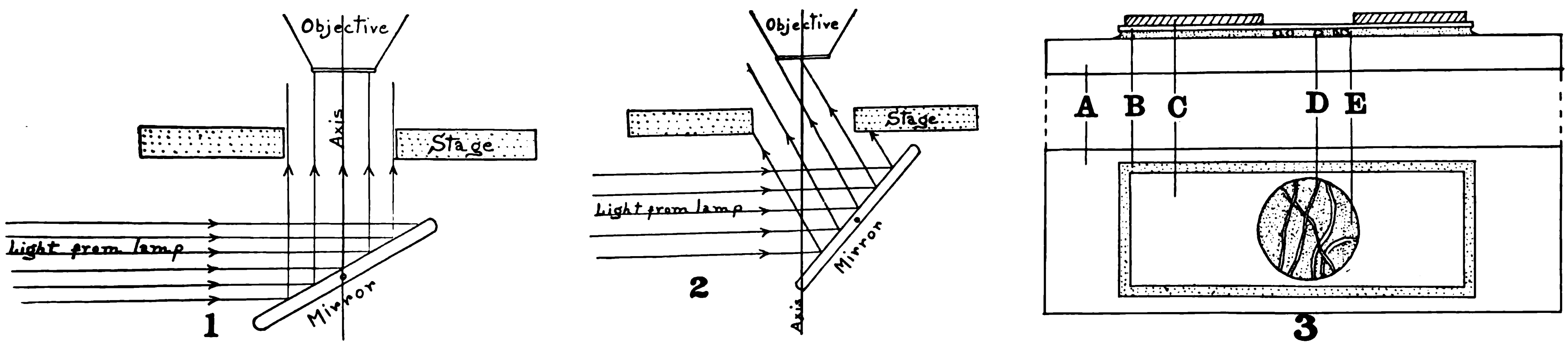


1. Diagram of the microscope stage, with the mirror set for vertical, or direct transmitted, light. **2.** How the stage is set for oblique light. **3.** The make-up of the fiber compressor: *A*, slide; *B*, cover glass; *C*, brass rectangle with circular aperture; *D*, fibers; *E*, mounting solution

Sketches showing the construction of the microscope stages and other apparatus employed by the author in the examination of textiles

Fabrics Under the Microscope

Some Methods in the Microscopical Examination of Textile Fibers

By Leon Augustus Hausman, Ph.D.

DURING the past few years the microscopical examination of textile fabrics has been gaining in favor with investigators as a ready and sure means of identification of the stuffs used in weaving and spinning. In a recent contribution to this paper (Hairs That Make Fabrics, Feb. 21, 1920), the writer described some microscopical methods and results in the examination of the commonest mammal hairs used in the textile industry. In this paper it is his aim to recount some of the processes of treatment in the microscopic examination of the vegetable and artificial fibers, which he has found to be the most useful in identifying the materials used, detection of adulterants, and so forth.

The textile fibers of commerce may be divided into four great classes: animal, vegetable, mineral and artificial fibers. The animal fibers, *i.e.*, hair and silk, are essentially nitrogenous in composition, that is to say, are composed of substances classed under the general name of proteids. Animal fibers often contain sulfur, and when burning give out a peculiar, pungent, characteristic empyreumatic odor, by means of which it is often possible to distinguish fabrics of animal from those of vegetable derivation. Alkalis attack animal fibers, causing them to dissolve, or tend to do so, but the action of mineral acids is withstood to a considerable degree.

Plant fibers, on the other hand, lack nitrogenous compounds almost entirely, and are composed of woody material, called cellulose, starchy in nature, and burn readily, giving off little or no odor, and being reduced to a fine whitish ash. Unlike the animal fibers, also, they are readily attacked by such acids as sulfuric and hydrochloric.

Mineral fibers are of rare occurrence in the textile industry, and are confined chiefly to the various kinds of the mineral of the same name. Asbestos, in nature, occurs as a mineral compound of silicate of magnesium and calcium, together with iron, and occasionally with a slight proportion of manganese. Though it is found in a hard state, not unlike feldspar, it can be readily split up and separated into multitudes of whitish or greenish, slender, tough, flexible fibers. Some species of asbestos furnish straight fibers, others curly ones. It is the latter varieties that are chiefly used for spinning.

The artificial fibers are of two sorts: those which are of mineral, or inorganic origin, and those derived from vegetable products. The former group embraces such fibers as spun glass, metallic threads of various kinds, and slag "wool"; the latter comprises the various artificial silks. Spun glass fibers are prepared by various processes which draw out the molten glass into very fine threads which harden at once by reason of their rapid cooling. Glass fibers are sometimes used as the weft of silks, where they impart an unusual heaviness and glancing luster to the cloth. Slag "wool" is prepared by blowing steam strongly through a mass of molten slag, producing a fluffy, wool-like substance. This is little used in spinning, however, and cannot strictly be called a textile material. Its chief use is for packing. Various metals, such as gold, silver, copper, etc., are drawn out into fine threads and used to a considerable extent in working into the designs in heavy brocades, trimmings, passementerie work, embroideries, church vestments, tapestries, etc.

The artificial fibers, strictly so-called, are the various artificial silks, composed of cellulose—the woody material of plants—and prepared, in general, by dissolving this substance in some suitable medium, *e.g.*, ether and alcohol solution, and then forcing it through very fine openings. The thin streams of the solution quickly solidify, due to the rapid evaporation of the solvent medium, leaving behind the delicate threads of cellulose. Because of the glossy, smooth surfaces of these fibers (see Figs. 6, 7, 9) they reflect the light readily and hence assume the lustrous appearance of the true silk fibers.

The microscopic investigation of textile fibers, of all derivations, has in the main been confined to examination under the microscope by what is known as transmitted light, *i.e.*, light reflected from the mirror beneath the stage of the microscope up through the specimen, and thence into the microscope tube. Often the specimen under examination is bathed in oil or water, to render it more transparent, and more easily penetrated and illuminated by the light rays. In the examination of mammal hairs the writer has utilized several other methods of lighting and mounting, which have also yielded excellent results when applied to the study of other textile fibers. These, and the results which they afforded, are here described, in the hope that they may prove useful to microscopists engaged in textile examination.

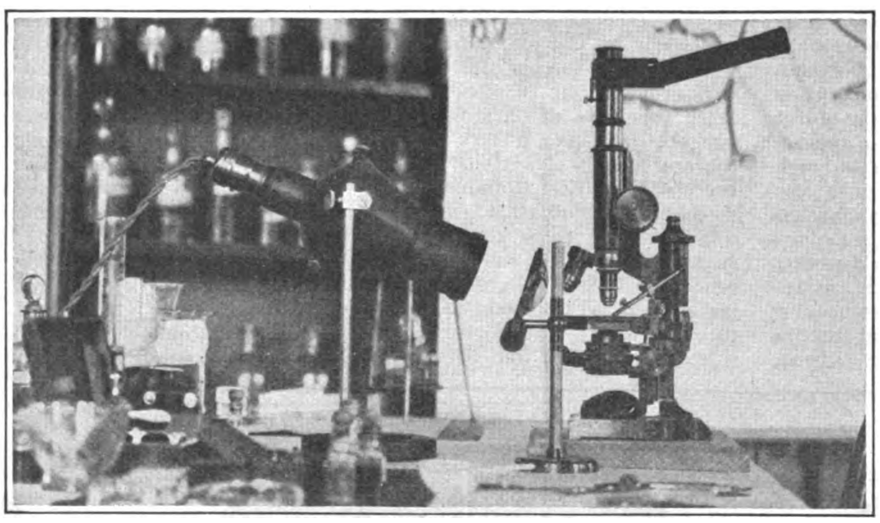


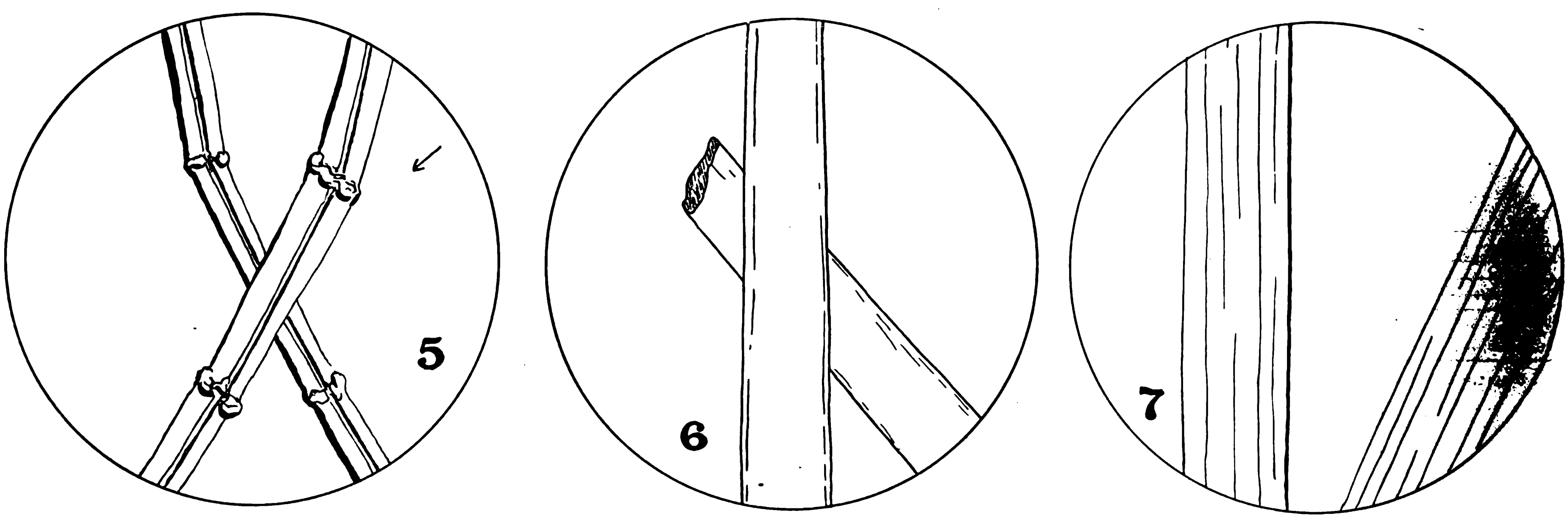
Fig. 4. Microscope, condensing lens (on stand) and microscope lamp arranged for examination of object by dark field illumination, using reflected light. Here the object receives light directed upon it from above

The equipment for the examination of mammal hairs and textile fibers should, for general work, consist of: a good compound microscope, with a triple nosepiece, bearing a 16-millimeter, a 4-millimeter, and a 1.8-millimeter (oil immersion) objective, and being equipped with a complete substage attachment, including a special "paraboloid" condenser, for use in dark field illumination. Furthermore, there should be available for use at least three eyepieces, or oculars, giving different powers of magnification with the different objectives, and an ocular micrometer for micro-measurements. A movable type of microscope lamp is a necessity, fitted with "daylight glass," and provided with other glasses of different colors. A short-focus lens or condenser is convenient, for concentrating the light where it may be needed. There are other microscopical accessories which are convenient, and when once used, apparently indispensable; but the equipment mentioned above will serve all practical needs. The slides and cover-glasses used are of the ordinary sort, and must be kept scrupulously clean. Forceps, dissecting and teasing-out needles, scalpels, scissors, pipettes, and all manner of instrumental accessories can be multiplied *ad libitum*.

The commonest method of examination of textile fibers is with transmitted light. This method gives good results in many cases, and yet does not bring out the delicate striations, or other characteristic markings upon which the identification of many of the fibers depends. In order to render these more clear, staining is often resorted to, yet this also is a more or less rough-and-ready method. Striations, folds, grooves, etc., when lying in a beam of light parallel to the optical axis of the microscope, *i.e.*, parallel to that beam of light which enters the front lens of the objective and leaves the center of the eye lens of the ocular, are often almost wholly invisible. This is not the case when the light from the mirror is oblique with reference to a line from the eye of the observer to the object under examination, so that it illumines the fiber from one side, and causes shadows to be cast by each depression or elevation. Figs. 1 and 2 illustrate the principles of vertical and oblique lighting when applied to the microscope.

Oblique illumination can be modified in various ways to meet different needs. It can be sent into the object on the slide either from the right or from the left, from in back or in front of the stage aperture, and at angles of varying degrees in any of these positions. Colored light from the microscope lamp has sometimes been found useful for demonstrating markings, especially pigment patterns in some of the finer hairs used in weaving. The color and intensity of the illumination, as well as the optimum angle of obliquity of the light rays, are elements which must be worked out empirically for each specimen under observation.

In examining certain fibers which it was desired not to stain, and yet which, because of their uniform hyalinity it was difficult to illumine properly, the writer utilized a device which will be termed a *fiber compressor* (Fig. 3), consisting merely of a rectangular strip of heavy brass, bearing a circular aperture in its center. The fibers designed for examination were placed upon a slide covered with a cover glass, irrigated with a colored liquid, and slightly compressed by placing the brass slide over the cover glass. The result was a group of fibers, showing clearly their outlines against



5. Fibers of linen from the winding sheet of an Egyptian mummy, viewed by oblique light; the arrow indicates the direction in which this fell. 6. American-made artificial silk of cellulose, viewed in safranin solution in the compressor. 7. Italian-made artificial silk, seen under similar conditions

What the microscope shows us of textile fibers from various sources

a background of solid contrasting color. In other words, instead of staining the fibers and examining them against a white field, the field was stained and the colorless fibers examined against it. This method proved very successful with such fibers as some of the artificial silks, where a natural, not a stained, appearance was the end in view. The stains used for the fiber compressor were: a saturated aqueous solution of safranin, of methyl green, of gentian violet, or of Bismarck brown. These were made up and diluted to the required depth of color for each specimen. Figs. 6 and 7 show, respectively, American cellulose acetate silk and Italian-made cellulose zanthate silk, both examined in the fiber compressor in safranin solution. Various excellent differential lightings for bringing out a wide variety of markings in fibers can be had by utilizing the fiber compressor with both transmitted direct and oblique illumination, and various colors both of the light, and of the "background solution" or mounting medium of the fibers.

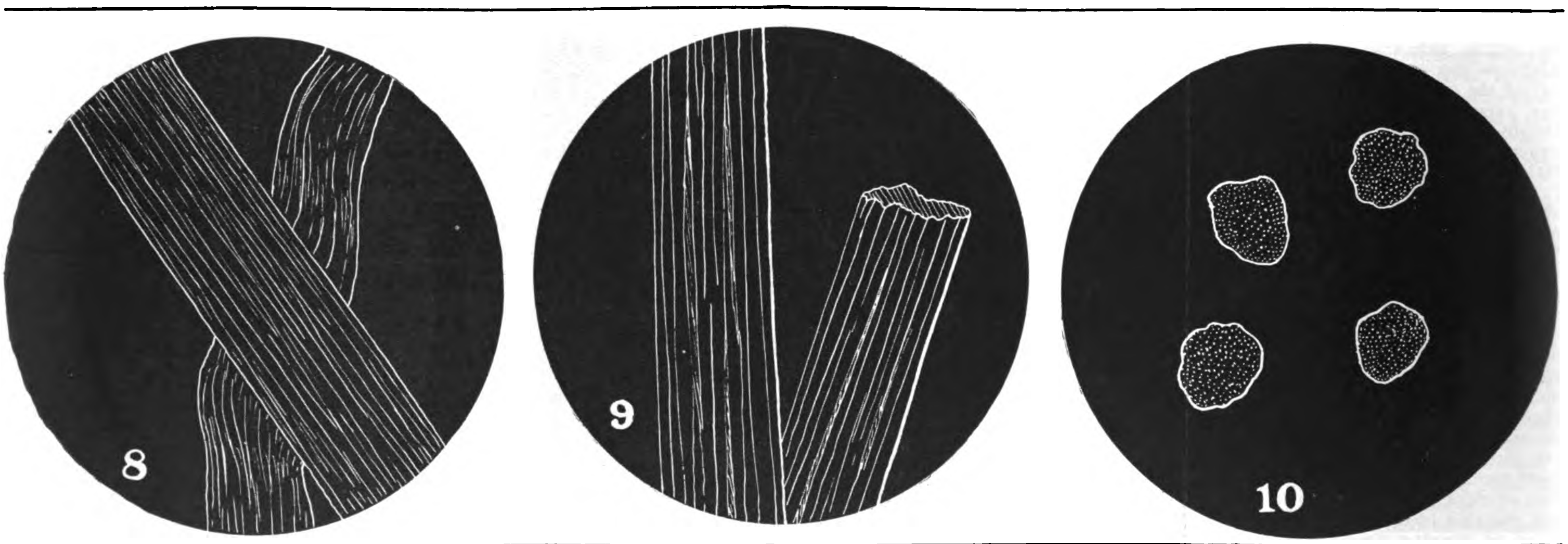
Dark field, or dark ground illumination, seems to be little used or little understood except by microscopists, and yet it is one of the most fertile methods of examination of delicate objects. By dark field illumination is meant that form of illumination by which the object appears light and the background dark. The appearance of objects under dark field illumination is much like that of the stars and moon against an inky sky at night. In order to be available for examination under dark field illumination, the object must be mounted on a slide in a medium of different light-refracting character, and must itself possess either strongly refracting, or reflecting qualities. Such conditions are usually fulfilled by mounting any of the transparent textile fibers (*e.g.*, the artificial silks, natural silks, linens, etc.) in Canada balsam, or some heavy oil, such as oil of cedar, or castor oil. Only such light as is intercepted by the objects under examination, reaches the eye, hence the appearance of a brightly lighted object upon a black field.

Dark field illumination can be had in several ways. The simplest method is to cover the aperture in the stage with a piece of black velvet (since this reflects so little light, even less than carbon paper), and then concentrate, upon the object on the slide, the light from the microscope lamp, using for this purpose a condensing lens mounted on a stand (Fig. 4). With such an arrangement, a very small fraction of the light from the condensing lens is reflected back into the microscope tube, while the object itself appears brightly illuminated. Such treatment works well, however, only with those fibers which are more or less opaque, the transparent, glassy fibers demand a modification of this method. This modification, designed for those fibers, which refract well, but do not reflect the light (such as the transparent artificial silks) consists in mounting them in Canada balsam, and illuminating them with the light from the substage mirror, using the dark-ground stop, furnished with all Abbé condensers. With this type of dark field lighting, the object still appears light upon a dark ground. Figs. 8 to 13 show the appearance of various textile fibers under the two types of dark field illumination just mentioned.

Oblique illumination can also be made to yield somewhat the same results as illumination with the substage condenser and central stop, by swinging the condenser to one side, or removing it from its mounting entirely, so that only the stage, with its large aperture, remains. The mirror is now swung far to one side and turned so that its reflected light-beam reaches the object on the slide very obliquely. If the light is sufficiently oblique, none will enter the objective except that which is intercepted by the object on the slide, which will, therefore, appear light upon a dark background. This method possesses the disadvantage, however, that it can be used only with low powers, *e.g.*, with the 16-millimeter objective, and furthermore that the object itself is illuminated only on that side from which the light proceeds.

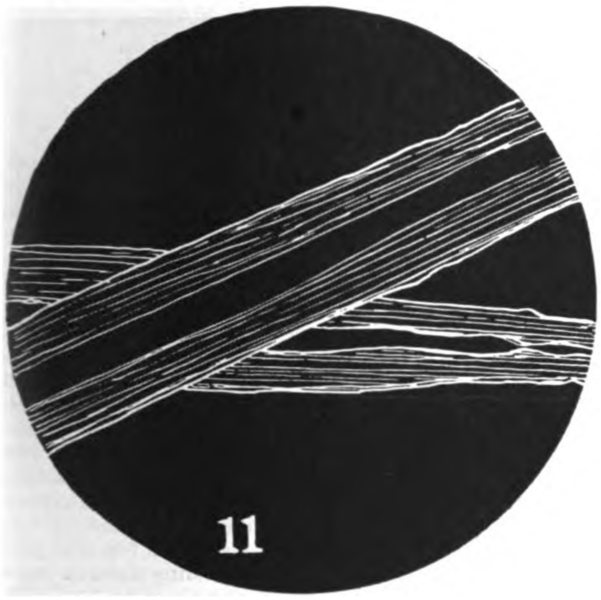
Excellent results have been obtained by a combination of transmitted light (either vertical or oblique), and the first type of dark field illumination, in which the condenser on a stand was employed. With this type of lighting the fibers were mounted in some light oil (or glycerine, as has been recommended), such as oil of amber, oil of bergamot, oil of cayeput, oil of wintergreen, and oil of clove. Xylol and water were often also used as mounting media. The reagent which afforded the most satisfactory results, however, was oil of amber, with which the fibers were thoroughly saturated after having been washed (in the case of the natural fibers) with a solution composed of equal parts of ether and 95 per cent alcohol, or (in the case of the artificial fibers) with hot soapy water, to remove any oily matter from their surfaces. The velvet cloth was not used in this connection, as it would have interfered with the passage of light from the substage mirror. Two sources of illumination were sometimes used, one above the stage for the condenser, and one below, for the mirror, and in this way light of different colors and varying intensities could be employed. Figs. 14 to 16 show various textile fibers subjected to this method of examination by double lighting.

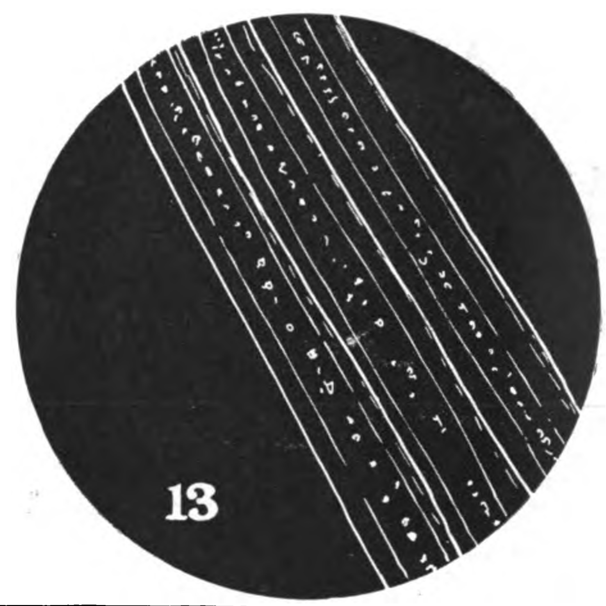
For the permanent mounting of textile fibers, the



8. Tussah, or wild silk. 9. American-made cellulose silk. 10. The same fabric in transsection

Three dark-field views of silk fibers from different sources





11. Jute. 12. Sea-island cotton in cross-section. 13. Flemish flax.

Three more dark-field exhibits

writer has found that Canada balsam and glycerine jelly answer all practical purposes. It is believed to be better, however, to keep textile samples filed away in envelopes, in a classified card-catalog system, and make preparations freshly when needed for comparison. In this way special methods of mounting in different media, for special methods of illumination, can be applied to each individual set of fibers, which would not be possible were they mounted once for all in Canada balsam or glycerine jelly. Each set of fibers should be determined, the determination noted on the envelope, and the envelope filed away where it can be at once available. Each envelope should bear, moreover, an account of the treatment found best to bring out the characteristics of the fiber, on which indubitable determinations can be based.

The enormous saving of time, labor and expense, together with the accuracy of the results of identification which microscopic analysis makes possible, should commend itself to all those who are working in the field of textile identification for the establishment of a system of uniform nomenclature of textile products.

Swimmer's Cramp—Its Causes and How They May Be Avoided

By J. S. Taylor, Captain, Medical Corps, U.S.N.

SWIMMER'S cramp is a spasmodic contraction of a muscle or group of muscles, as in the calves of the legs, the arms or the belly wall. Muscle cramp or tetanic contracture results from what is called summation of stimuli. The repeated and rapid contraction of a muscle induces fatigue and then temporary paralysis. The degree of fatigue necessary to produce spasm would, of course, depend on the tone of the muscle. A weak, undeveloped muscle would become fatigued sooner than a well developed one. An important factor in muscle spasm is the accumulation in the local circulation of waste products incident to exercise known as "fatigue stuffs." These fatigue stuffs undoubtedly act as a chemical irritant to the muscle, increasing its susceptibility to tetanic spasm. Therefore, the activity of the local circulation is of immense importance in this connection.

In Asiatic cholera the enormous reduction of body fluids by diarrhœa increases the viscosity of the blood and produces marked interferences with the capillary circulation. In this disease the patient experiences very distressing cramps in the muscles of the abdomen and of the calves of the legs.

Men who work in the hot firerooms of ships, especially inexperienced firemen, suffer from similar muscular cramps. They work hard, drink a great deal of water, cold as they can get it, perspire profusely and often chill the body surfaces by standing half naked under blowers and ventilators.

With normal exertion of a muscle of good tone and with a normal circulation, tetanic spasm will not occur. The weak muscle or the over-stimulated muscle tends to spasm, and spasm is further favored either by an excess production of fatigue stuffs or by the deficiency of the local circulation on which the removal of these fatigue stuffs depends. In the case of the cramps developing in cholera the circulatory disturbance is the chief one. The muscles are insufficiently nourished, enfeebled, and so predisposed to spasm from the smallest degree of exertion and the capillary deficiency prevents the removal of the chemical products of muscular contraction.

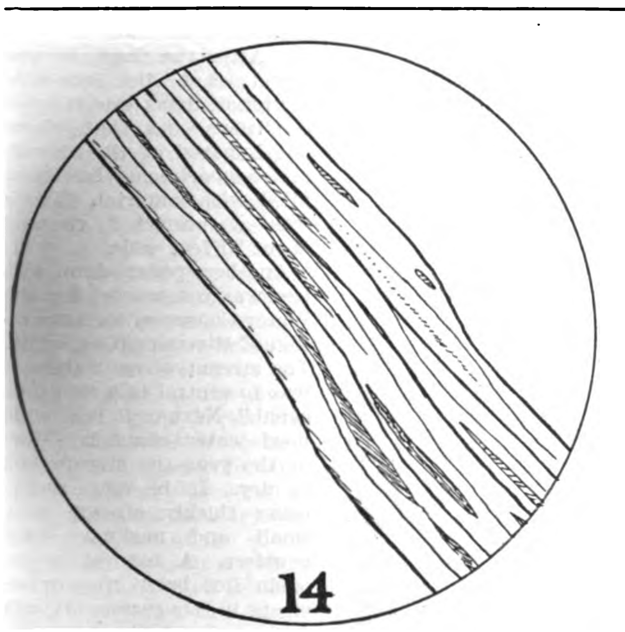
In the case of firemen, the over-use of the muscles and disturbances of circulation act together in producing cramps. The profuse sweating reduces the total bulk of body fluids and the chilling of the body surface, along with the consumption of large quantities of water, tend to cause a congestion of the internal organs with a consequent collateral anemia in the superficial blood vessels.

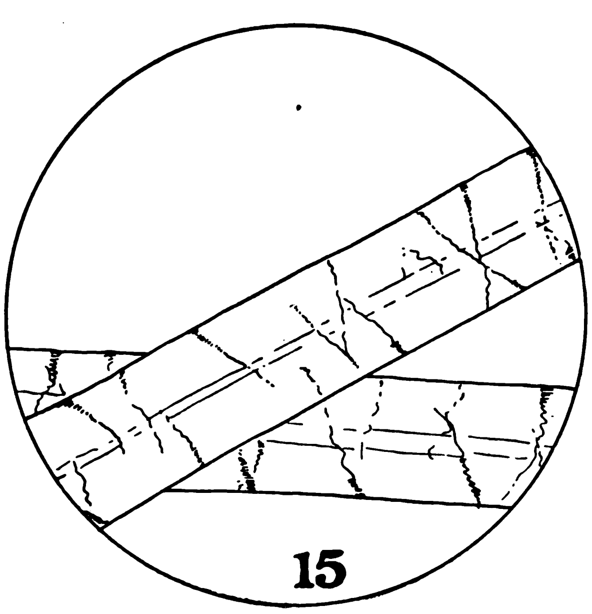
Practical conclusions to be drawn from these facts in relation to swimmer's cramp are simple. Do not stand about at the water's edge too long before entering the water. While it is a mistake to plunge in when the body is greatly overheated, it is just as bad to wait a long time to cool off first. Do not go in swimming after a hearty meal or after consuming large quantities of water. Several hours should intervene between a big meal and swimming.

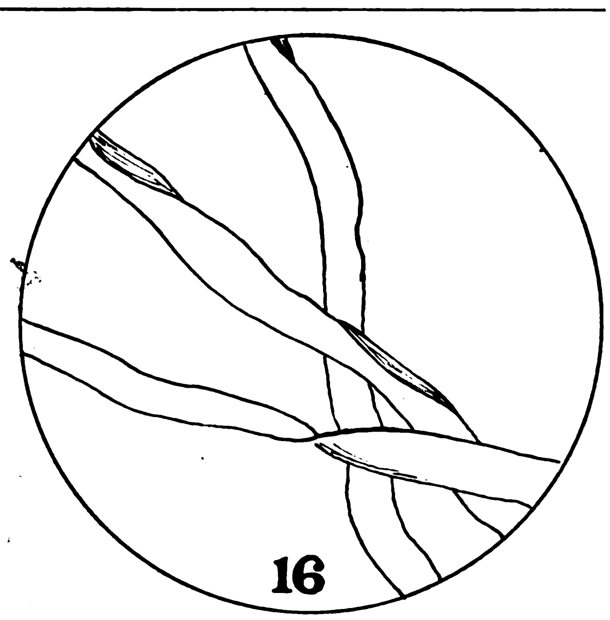
In the next place, when considering swimmer's cramp, it should be remembered that swimming is a very active exercise, calling into play nearly all the voluntary muscles of the body and it is easy to overdo. The amount of exertion which can safely be made in the water without liability to muscle spasm depends in part on muscle tone. The person who takes comparatively little exercise on land, whose muscles are more or less soft and flabby, cannot reasonably expect to make undue calls on his muscles without unpleasant and dangerous consequences when he is exercising in the water.

It is possible that swimming in very cold water may increase the tendency to cramps. Even when exercising only moderately, most people stay in bathing too long, cramps may come from long-continued moderate use of the muscles just as readily as from excessive use of them for a short time.

Considering the large number of deaths that occur annually through swimmer's cramp, more thought and care should be accorded this subject. In many instances it is due to carelessness or lack of knowledge.







14. Japanese mulberry silk, in oil of amber. 15. Purified French ramie linen, under the same treatment as the last. 16. Unmercerized cotton in oil of bergamot. Note the absence of twist

Three different fibers as seen under Dr. Hausman's double-illumination technique