Identification of Death by Drowning by the Disorganization Method (Diatom Method) *1

Tokuro TOMONAGA *2

Department of Legal Medicine, Nagasaki University
School of Medicine, Nagasaki, Japan

Received for publication September 3, 1960

The diatom method is the most reliable to determine whether or not a cadaver found in water is a case of death by drowning. Studies on the distribution of diatoms in fresh and sea water have found them present in all sorts of natural water including subterranean water, rain water from waterworkers, and even in the soil. Therefore, a death by drowning in whatever sort of natural water can be identified by the diatom method. If one dies after drowning, the water enters into the organs of the systemic circulation through the lung and at the same time into the stomach and intestine. If one dies before being thrown into water, the water enters into the lung and the stomach, but never into the organs of the systemic circulation nor into the duodenum and other distal parts of intestinal tract. For the diatom method the other suitable organs for examination beside the lung are the liver and kidney, the examination of the contents of the stomach and intestine for diatoms also being important. The time and place of death by drowning can be determined by the diatom method. Whether drowning has taken place in river or sea is easy to tell by resorting to the diatom method, being available even for a skeletonized body. This disorganizing procedure of the diatom method is usually carried out on a sand dish, although special purpose of examination requires heating on a water bath.

Determination as to whether a cadaver found in water is a case of death by drowning or postmortem abandonment is very important in the practice of forensic medicine, since that determination is a basis on which to judge whether the case is a suicide or stems from foul play. The identification of death by drowning has long been an important subject of study, on which a great many reports are available. Despite its rich documentation, the question is actually not yet solved definitely. Macroscopic findings in the cadaver, including froth in the air passages and the inflated lungs, are not very helpful in the identification of death by drowning, as is generally admitted. On the dilution of blood in the left side of the heart by drowning water, there are reported ten-odd methods of examination; none of them is reliable enough for practical use, another fact which also is common knowledge. The only method useful for definite identification of death by drowning, is the disorganization method or the diatom method (hereinafter, the d.m.) by which the floating organisms in water, diatoms, are detected and determined. Reported demonstration of planktons in the lung of cadavers found in water seems to date back to many decades ago. Diatoms have come to be regarded as more important since the

---

*1 A report read before the 38th convention of Medico-Legal Society of Japan, held in 1954.
*2 友 永 得 郎
reports of Hofmann \(^{39}\) in 1896, Reinsberg in 1901, etc. Methods of examination for diatoms were further described by Revenstorf \(^{14}\) in 1904, Kasparek \(^{5}\) in 1937 and Buhtz u. Burkhardt \(^{13}\) in 1938. In recent years, B. Mueller \(^{10}\) \(^{31}\) and his students (1949 to 1953) have reported on this subject.

Necessity, in the field practice of forensic medicine, for the definite and reliable identification of death by drowning, has prompted the present author to these studies. Reports on the identification of death by drowning by what he calls the d.m. have been presented before academic and other meetings \(^{18}\)^{19}\(\) several times since 1938. In the d.m., for easier examination for diatoms, the sample is treated with nitric or sulfuric acid or is strongly heated to eliminate those organic substances in the sample which would otherwise interfere with microscopic examination.

To what extent the d.m. is actually efficient, is the theme of this paper, which also describes diatoms entering the blood flow in the course of death by drowning and diatom entering the body after death, dividing the discritions into the following 5 chapters; (A) how to carry out the d.m. and how to detect diatoms; (B) the distribution of drowning water and diatoms in drowned bodies; (C) postmortem intrusion of water and diatoms into the body; (D) the distribution of diatoms in nature; and (E) the identification of drowning in the night-soil reservoir.

**A) How to carry out the d.m. to detect the presence of diatoms**

(1) The d.m. can be classified in the following four methods according to the intensity of the procedure; (a) the d.m. at low temperature (room temperature); (b) the d.m. in a water bath (60 to 100°C); (c) the d.m. on a sand dish (200 to 300°C); and (d) the d.m. in a crucible (about 500°C).

The author is accustomed mostly to resort to the method (b), which, however, has this drawback: this method does not always assure the complete removal of undesirable organic substances from the contents of the stomach or intestine or from pulmonary tissue containing many coal particles, and thus makes it occasionally difficult to identify diatoms. This difficulty is lessened to some extent by resorting adequately to the method (d). This method (d), however, should not be carried out to strongly, as otherwise the diatoms would be lost. The method (c) removes coal particles and other undesirable substances completely, with relatively little loss of diatoms. The method (a) which is for use when the amount of undesirable substances present is low, has the advantage of minimizing the loss of diatoms, and is, therefore, indicated in the examination of newborn organs and tissues for diatoms.

Heating in the course of the d.m. results occasionally in the loss of some types of diatoms. Salt-water diatoms generally tend to be more sensitive to disorganization procedures than do fresh-water types. Several types of the salt-water diatoms survive the method (a) but become almost completely lost by the method (b). While many types of the salt-water diatoms are in the form of cluster, the treatments involved in the d.m. result in the separation of the cluster into the individual cells. In some other types of the salt-water diatoms, only those parts of each cell which are more resistant than the rest are unaffected by the d.m. Several types of animal planktons are able to survive the d.m.

(2) Even when drowned in water containing a very small count of diatoms (e.g. 13 cells per 100 cc), 20 g of lung tissue yielded 32 cells of diatoms. Diatoms can also be demonstrated from other tissues, if larger samples are examined.

(3) The d.m. on a sand dish is carried out as follows. Place 10 g of a sample in a Kjeldahl flask, add therein about 2 to 4 cc of fuming nitric acid, and allow it
to stand for 10 minutes. After the foaming has become somewhat weaker, subject the above to strong heating on a sand dish. When the foaming has decreased, add fuming nitric acid again, this time 3 to 5 cc. On observing the sample melt after about 5 to 10 minutes, and therein about 5 cc of concentrated sulfuric acid, and continue heating. There is then a color change from brown to black within 20 to 30 minutes. Then, heat for several more minutes, add 5 to 6 cc of hydrogen peroxide water cautiously, and heat. Then, the sample will be found colorless and transparent. If at this time any black lumps of small size remain in the sample, remove them by adding 1 to 2 cc of fuming nitric acid. When colorless and transparent condition has been reached, centrifuge, remove the supernatant, and microscopically examine on an object glass. If slight cloudiness is present all over, centrifuge, remove the supernatant, and replace the supernatant with distilled water. By this procedure, the cloudiness will be removed. It is desirable to wash the sample with distilled water, dry it on an object glass, and seal it with balsam before microscopic examination. Addition of distilled water at this stage may occasionally produce a sudden cloudiness, in which case add sulfuric acid once more and repeat the d.m. The heating on a sand dish under the method (c) is replaced, in the case of the method (b), by heating in a water bath. Under the method (b), the tissue is dissolved and the supernatant is transparent and light yellow in color. The method (b) is the most suitable for the identification of drowning of newborn child in a night-soil reservoir.

B) Distribution of drowning water and diatoms in drowned body

As far back as in 1857 and 1889, Dëhne and Paltauf, respectively, reported on the intrusion of drowning water through the alveoli of the lung into blood. This report was confirmed by Fränkel u. Strassmann (1914) and numerous subsequent workers. Many attempts have been made, as is well known, to utilize the dilution of blood in the left side of the heart in identification of drowning. Revenstorf in 1907 and other subsequent workers have dealt with the presence in the blood of solids coming from the drowning water. Intrusion of diatoms into the organ of systemic circulation was described by Incze in 1942, Gorcs in 1949, and Mueller in 1952. In our own studies on intrusion and distribution of drowning water in the body, we employed P32 as a tracer; animals were drowned in a solution of P32 and then examined. As for the entry of diatoms into blood, we carried out elaborate studies on experimental animals drowned in the suspensions of diatom earth and in natural water and on human drowned bodies. These studies have resulted in the following knowledge:

1) With P32 level in the drowning water taken as 100, P32 level in the lung was 140, in the blood in the left side of the heart 50, in the blood in the right side of the heart 15, and in most other tissues 0.2 to 1.6. In the cat, P32 concentration was high in the upper lobe of the lung and low in the lower lobe. The P32 concentrations vary more or less with each animal. However, the presence of P32 in the stomach and the upper part (30 to 50 cm) of the intestine was demonstrated in all animals examined.

2) In cats, the amount of water that entered the body was noted to be 2 to 10 per cent of the body weight; and in the course of drowning, the amount of water that entered the body at 20, 40, and 60 seconds was noted to be 2.5 per cent, 4 per cent, and 10 per cent, respectively, of the body weight. Of the drowning water in the body, three-fifths were in the lungs, and two-fifths were distributed over the other parts of the entire body.

3) The distribution in the body of diatoms contained in the drowning water
does not coincide with the distribution of $^{32}$P in the body. With diatoms of the drowning water taken as 100, their presence in the lungs ranged from 200 to 1,300, and in the other tissues from 1 to 25. The types and counts of diatoms in the lung were approximately in agreement with those in the drowning water. The presence of diatoms was demonstrated in the brain, liver, kidney, spleen, pancreas, muscle, bone marrow, bile, urine and even in the fetus. The contents in the duodenum occasionally flow back into the pancreas; the same situation is also conceivable with bile.

4) Some types of diatoms are less apt to enter blood. They are, for example, Skeletonema, Chaetoceros, Bacteriasitrum, Rhizosolenia, etc. which occur in salt water. The maximal sizes of diatoms passable through the alveolus of the lung were found to be $122 \times 45\mu$ and $144 \times 32\mu$, the maximal passable length $160\mu$, and the maximal passable diameter $100\mu$. In practically all the samples of fluid obtained from the drowned thoracic cavity, diatoms were demonstrated at an average rate of 15 cells per 50 cc.

5) Animals were experimentally drowned in a P$_{32}$ solution after subjecting them to deep anesthesia with ether, deep anesthesia with chloroform, a heavy blow on the head, poisoning with prussic acid, strangulation, cutting of the femoral artery, cutting of the carotid artery, heart stabbing, lung stabbing, etc., respectively. In these animals, the concentration of diatoms in blood was generally low, though the blood diatom level was more or less dependent on the intensity of the pre-drowning damage. The diatom level was especially low in the intestine, and was low to some extent in the lung. The longer the course of drowning, the lower, markedly, was the diatom level in the lung. Effects of aerothorax were not significant. Following deep intoxication with alcohol, Calmotin (Bromvalerylurea) poisoning, or Adorm (Aethylhexabital, Calce.) poisoning, the concentration of diatoms was somewhat higher in the lung than observable under ordinary conditions, and was markedly low in blood and tissues.

6) In order to know the destination of diatoms that entered the lung before death, diatoms were counted in animals taken out of water in the initial stage of the drowning process and also in those allowed to inhale diatom dust. In the former, the diatom count after 16 days survival and after 340 days survival was 8 per cent and 3 per cent, respectively, of the count noted immediately after the procedure; in the latter, the comparable figures on 10 days and 105 days survival were 60 per cent and 3 per cent, respectively. In none of these, the presence of diatoms in the blood could be demonstrated.

C) Postmortem entry of water into the body

That water can enter the lungs of the body placed in water after death was recognized as far back as in 1862 by Liman$^7$ and in 1884 by Lesser$^9$. However, it was considered that the water generally did not reach the periphery of the lung except under exceptional situations. Solids (diatoms) of water demonstrated beneath the pulmonary pleura have been interpreted to indicate drowning. This interpretation has been supported by Serebrovianikov u. Golajev$^{16}$ (1928), Lacroque u. Merchand$^8$ (1931), Mueller$^9$ (1932), Schrader$^{17}$ (1937), Merkel u. Walcher (1945), and others. Recently, however, Mueller$^{11,13}$ et al. (1952 and 1953) observed diatoms to find their way even to the periphery of the lung and into some blood areas, if the water-pressure was high. In this relation, we carried out an elaborate experiment. Placing dead animals in a solution of India ink or P$_{32}$ with floating diatoms under high pressure it was determined how the water influenced by water-pressure finds its way into the body under varying conditions. Also, some cadavers were sunk deep into the
sea, and the effect of water-pressure was studied.

1) The intrusion of India ink solution to the periphery of the lung in cats at 50 to 30 meter depth was 100 per cent of the entire surface area of the lung, at 10 meter depth 90 per cent, at 5 to 2.5 meter depth 70 per cent, and at 1.5 to 1 meter depth 30 to 40 per cent. At 0.5 meter depth or less, India ink was found only in the trachea (when in prone position). Difference in the duration of pressure produced little difference in the above values. The water intrusion was remarkably interrupted in the adherent lungs, and was also influenced to some extent by rigor and putrefaction. Difference in the degree of water intrusion due to the cause of death was occasionally observed. For instance, the entry of water into the body is impaired following death by strangulation, especially when the course of strangulation had been long. The water intrusion is markedly inhibited in drowned bodies; on many occasions, no intrusion of water at all takes place even under a pressure of 50 meter depth. However, the longer after drowning, the more easily water entered the body.

2) Water intrusion into the stomach was observed in 11 per cent of 107 cases examined. The degree of this water intrusion is not always in proportion to the intensity of the pressure. Nor is any close relationship observed with the cause of death and the amount of food present in the stomach. The water intrusion is facilitated to some extent by putrefaction and interrupted to some extent by rigor. The intrusion of water into the duodenum was observed in none of the cases studied. Water intrusion into the rectum was observed in 21 per cent of the cases studied.

3) When the dead body had been subjected to various treatments:

   Tight binding of the chest and making a hole in the chest wall considerably interfered with the intrusion of water. Incision of the abdominal wall, stab wound of the lung, aerothorax, and tight binding of the extremities strongly interfered with the intrusion of water according to the intensity of these manipulations (different from the observations in the case of drowning to death). Artificial respiration in the water allowed water to enter the body to some extent; artificial respiration after taking the body out of the water permitted a small amount of water intrusion. Intrusion of water in a trace amount was observed in the body simply rolled repeatedly in a prone position.

4) No intrusion of water was demonstrated in any of nonbreathed newborn infants subjected to pressure. Even in infants born alive, the degree of water intrusion was but little.

5) When adult cadavers were lifted from the sea after 30 minutes immersion at a depth of 23 meters, white froth came out of the mouth and noses as in the case of drowning. The lungs were a little swollen and had the appearance of a drowned lung of moderate degree. Salt-water diatoms were demonstrated in large numbers in the lung, in a very small number in the heart blood, and none were found in the organs.

6) Following postmortem pressure, the number of diatoms in the lung was about one-quarter of that in death by drowning, and its distribution was not uniform. When subjected to pressure in a $P_{32}$ solution, the concentration of diatoms and $P_{32}$ in the lung was about one half of that in death by drowning. The lung diatom and $P_{32}$ level in the case of pressure after drowning was found as markedly low as in the case of pressure in India ink solution. The diatom and $P_{32}$ level was often higher in the blood of the right side of the heart than in the blood of the left side of the heart. Diatom and $P_{32}$ intrusion took place also into the vena cava superior and vena cava
inferior. The diatom and P₃ level in the stomach and intestine was the same as in the case of India ink solution.

D) Distribution and the increased or decreased occurrence of diatoms in nature

The results of studies thus far described indicate how diatoms are important in identification of death by drowning. Definite knowledge on the distribution of diatoms in nature, on the types, and on increase or decrease of diatoms in nature, often enables presumption or determination of the time and place of drowning.

a. Diatoms in fresh water:

1) Examinations for diatoms were carried out in 5 reservoirs of water in the periphery of Nagasaki city and in the Urakami river (at 10 points on the river, with a distance of 300 to 500 meters between each point throughout one year. The types of diatoms and the number of their cells varied considerably with the areas of these examinations. Some types of diatoms would increase or decrease abruptly. Generally speaking, when the total number of diatom cells increased gradually, the increase was noted to be uniform with all the types of diatoms occurring in the same area. The deeper in the water, the lower was the diatom count. But, when the water bottom had been stirred, the diatom count there became higher than that in the surface portions of the water, with no appreciable change in the types of diatoms. The diatom count is a little lower during rain than when the weather is fine.

2) Water from waterworks and subterranean water also contain diatoms to varying degree. Generally speaking, subterranean water and water welling from the ground contain the lowest count of diatoms of various categories of natural water. However, high counts of diatoms are observed in the subterranean water which is connected with the surface of the earth (20, 50, 200 and 1,300 cells per 100 cc). In the water of a reservoir, even as many as 6,700 cells of diatoms were present even after filtration. In the water from waterworks, the diatom count is higher, as distance increases from the filtration basin. The diatom count in the water from waterworks is closely related to the replacing of the filtering membrane. Filtration effect of 55 per cent before replacing of the filtering membrane has risen to 99 per cent 7 days after replacing the membrane with a new one.

3) Diatoms are present in rain-water, air, floating dust in the air, and, abundantly in soil.

b. Diatoms in salt water:

Extensive investigations of diatoms in salt water have been conducted by other workers from a different standpoint to ours, and their findings are not adequate enough for our purpose. As far as investigated by ourselves, the diatoms that occur in salt water alone in relatively high frequency and that are important for our purposes are of 20 types, about half of which may be regarded as highly important. These are Skeletonema, Chaetoceros, Rhizosolenia, Eucapnia, Thalassiothrix, Bacteriastrum, Asterionella, Melosira, Nitzschia, and Coscinodiscus. Some animal planktons are highly resistant to the d.m., An example of this is Dictyocha.

1) The multiplication of diatoms in the port of Nagasaki is observed four times each year. The diatom count varies with its type and time of occurrence. Even in such special waters as the southern parts of Omura Bay, diatoms are observed to multiply substantially twice each year. Surveys at 12 specific areas in the above-mentioned narrow waters revealed a great difference in the diatom count among the areas.

2) A significant difference in the type and number of diatoms occurring is present among different waters, even at the same time and at a particular level of
tide. Even in one and the same month, the diatom count occasionally shows a marked difference according to days (in consequence of weather and the ebb and flow of the tide). Even on the same day, the diatom count is lower at night and higher in the day time, and also influenced by ebb or flow.

3) At and near the estuary, the ratio of diatoms between salt-water types and fresh-water types differs considerably according to tidal ebb and flow. As the tide begins to flow, the advancing sea water proceeds into the estuary in a cone shape, influencing the distribution of diatoms accordingly. At the estuary, the salt-water diatoms show increase shortly after the full tide hour.

E) Identification, by the d.m., of drowning in the night-soil reservoir

Distinguishing whether an infant cadaver found in the night-soil reservoir is a case of drowning or postmortem dumping is not always easy. A mere microscopic detection of filth in the bronchiole is no sufficient evidence for death by drowning. A report has been read by the present author before our Society meeting that the simplest and the most reliable procedure for identification of death due to drowning in such a situation as the above lies in the demonstration of palisade cells (coming from bean paste) in the lung and other tissues, and that this demonstration is made easier and more reliable when the d.m. is employed.

The palisade cell comes from the shell of soy beans which are the raw material for bean paste. The palisade cell is highly resistant to digestion and putrefactive factors, and remains unchanged by the d.m., unless subjected to an intense disorganization procedure on a sand dish in which case they might be lost altogether. This procedure should be carried out in a water bath. We have noted that each gram of bean paste contains 15,000 to 200,000 palisade cells capable of withstanding the d.m. in a water bath. Palisade cells range in size from 17 x 20 to 80 x 140 microns, and are easier to detect than diatoms. In a certain examination, palisade cells 68 x 8 microns and 59 x 17 microns were also demonstrated to be present in the kidney, liver, etc., after having gone through the alveolar walls and entered the blood circulation. In the night-soil reservoir, not only palisade cells but also large numbers of diatoms were floating in consequence of the specific gravity. The diatoms, too, can be used as indicators in identifying drowning in the night-soil reservoir. It may be mentioned here that the upper portions of the filth of a public lavatory located in an area of congested traffic in the city of Nagasaki showed the presence in 10 cc. of filthy water of 20,736 to 30,386 palisade cells and 987 to 3,996 cells of diatoms on examination by the d.m. on a sand dish.

DISCUSSION AND CONCLUSIONS

Experiments and studies were done from various angles in order to determine with what degree of reliability the identification of death by drowning can be done by examining the lung and other tissues for diatoms which are solids in water. Examinations in this connection were done by what we term the disorganization method (the diatom method).

I) This method is classified in to four types according to the intensity of treatment involved: (1) disorganization at room temperature, (2) disorganization in a water bath, (3) disorganization on a sand dish, and (4) disorganization in a crucible. Which of the methods should be used in a given case depends upon the object of examination and the kind of sample available. In the course of the disorganization procedure, the microscopic examination of lung tissue for diatoms is
often made difficult by the presence of coal particles in the lungs of adults, especially of aged ones. The coal particles can, however, be removed completely by the d.m. (disorganization method) on a sand dish. This particular method is also indicated for the examination of gastric and intestinal contents. Several types of salt-water diatoms disappear by this procedure, but these several types are not important from the practical point of view for forensic medicine. When, however, any of these several types has to be demonstrated, the d.m. in a water bath or at a low temperature should be carried out. When the diatom count in drowning water is very low, the detection of diatoms in a cadaver from the water may be difficult. We may, however, quote here our experience that, following experimental drowning of animals in water diluted with distilled water to contain 13 cells of diatoms per 100 cc, the identification of their drowning therein could be made by the d.m. Such a low concentration of diatoms in water as above must be exceptional.

II) The distribution of intruded water in the drowned body was studied by experimental drowning of animals in water containing P32 and then measuring c.p.m. of P32 in the different regions of the body. The entry of diatoms into the blood was studied by animal experiments in diluted suspensions of diatom earth and in natural water and also by examination of drowned human bodies.

1) The calculated total amount of intruded water in the drowned cats was from 2 to 10 per cent of the body weight, about three-fifths in the lungs, and about two-fifths in all other parts of the body.

2) In animals severely damaged before drowning, the amount of intruded water present in the lungs and blood was found to be less than when drowning took place without such damage. In drowning following deep intoxication with alcohol or anesthetic agents, the diatom count was rather high in the lung and significantly low in the blood.

3) The distribution of diatoms in drowned bodies does not always coincide with the distribution of intruded water in the body, because the diatoms are mostly filtered by pulmonary alveoli. This filtration or trapping by the pulmonary alveoli is aided by the fact that many types of salt-water diatoms have spines or are connected together in the form of a cluster, and therefore, do not pass through the alveoli with ease. As for diatoms that have entered the blood, detection by the d.m. is not always difficult, since they can be filtered and demonstrated in various organs. Diatoms are detected not only in the various organs but also in the bone marrow, bile, urine, and fetus.

4) The maximal size of diatoms that can enter the blood has been stated by Mueller et al. to be about 30 microns. The maximal size of diatoms we ourselves have obtained from human bodies was 160 microns in length and 100 microns in diameter. For such a large solid to find its way into the blood, the following situation is believed responsible. Since the pulmonary capillary pressure is usually lower than in other parts of the lung and since the velocity of blood flow in the lung is highest when the alveoli are moderately distended (Nishimaru, 1952), extreme decline in the intravascular pressure between alveoli and the left ventricle of the heart in the course of drowning and the consequent strong negative pressure may be interpreted to induce the sucking into the blood of diatoms from the extremely distended alveoli and capillary stomata and also eventually from damaged blood vessels.

5) Other organs beside the lung which are suitable for the detection of diatoms are the liver and kidney. The myocardium is not suitable for this purpose.
6) In drowned human bodies, the intruded water usually reaches down to within 1 or 2 meters of the upper part of the intestine, occasionally further down in the intestine.

III) Experiments were performed in the postmortem entry of diatoms into dead bodies, by use of India ink solution, diatom earth suspensions, and a high-pressure tank, and also by immersion of the bodies at a maximum depth of 75 meters in the sea. It is known from these experiments that diatoms, under the influence of water-pressure, enter the lungs of bodies thrown into water after death, that a very small number of the diatoms pass through the alveoli and enters the blood of the left side and the right side of the heart, but that diatom entry into the organs of the systemic circulation does not take place at the water depth of 50 to 75 meters. The postmortem entry of diatoms into the lung is invariably less amount than following death by drowning (being one half to one third), and the distribution of diatoms is not uniform.

The entry of water into the lungs is occasionally interfered with according to the cause of death or when the dead body has been subjected to various manipulations, especially when the chest has been tightly bound or a hole is bored in the chest wall, as seen in the case of aerothorax and an adherent lung. Water intrusion into the stomach was observed in 11 per cent of the cases studied, while water entry into the duodenum was not noted in any of the cases examined.

Removal of a cadaver from the water, its transportation, or careless treatment at autopsy, may change the conditions of diatoms present in the lung, stomach, and intestine.

IV) Many types of diatoms are contained in large numbers in salt water as well as in fresh water. The variety of diatoms occurring in salt water differs considerably from that in fresh water. Their types and numbers also vary with the place and time of their occurrence. Therefore, a definite determination of the diatom composition (types, numbers and distribution) in the lung will sometimes permit presuming or determining the time and place of drowning. Especially important is, therefore, the relationship between the river and the sea and between the ebb and flow of the tide.

Diatoms are to be found almost everywhere; for instance, they are in subterranean water, from waterworks, rain water, in the air, and also in soil. Therefore, even drowning in a temporary pool of rain water can also be well identified by the d.m.

V) Identification of drowning in a night-soil reservoir is easy by resorting to the d.m. The filth in the reservoir contains large numbers of floating diatoms and palisade cells.

VI) Death by drowning can be identified by the d.m., even in a skeletonized cadaver. Identification of drowning should without fail resort to the detection of diatoms in the lung and other organs by the d.m., and this method alone suffices (with rare exceptions). Determination of the diatom composition in the lung, stomach, and intestine is very important in judging how drowning took place.

VII) Positive or negative result of examination for diatoms permits, as a rule, the identification of death as stated hereunder. (This examination must be carried out very carefully, since diatoms are almost ubiquitous. The utensils used in the examination must be washed clean with distilled water so that there are no stray diatoms present. Great caution is indispensable before making a decision that the result of the examination for diatoms is negative. Food-borne diatoms in the stomach and intestine must be excluded.)

(1) The diatom-positive lung does not always mean drowning.
The diatom-negative lung rules out drowning.
The diatom-positive liver and kidney confirm drowning.
The diatom-negative liver and kidney rule out drowning except in special cases.
The diatom-positive stomach does not always mean drowning.
The diatom-negative stomach rules out drowning.
The diatom-positive duodenum confirms drowning. (excluding diatom constituent in the food)
The diatom-negative duodenum rules out drowning except in special cases.
The diatom-positive bone marrow confirms drowning.
The diatom-negative bone marrow rules out drowning except in special cases.

REFERENCES