due to asphyxia from inhalation of smoke, or to actual burns of the respiratory passages and acute œdema of the glottis from the inhalation of hot air or flame. Post-mortem appearances in such conditions are discussed under *Asphyxia*. When death occurs from actual burns,—as may happen, for example, as a result of a conflagration,—it will be found that the extent of cutaneous surface burned is a more serious factor than the mere depth of the burn. Although cases have recovered in which a greater area has been involved, if one-third of the surface of the cutis is burned the individual usually dies. The cause of death in these cases may be shock, or it may be due, judging from post-mortem appearances, to the action of some poisonous substance either absorbed from the wound surface (namely, some ptomaïne-like product), or from the invasion of bacteria, or from an auto-intoxication due to suspension of function of the skin involved. The heart muscle and the epithelial cells of the liver and kidney present the appearances of parenchymatous degeneration, or, if death occurs somewhat later, of fatty degeneration. It has been reported that round ulcer of the duodenum is a frequent accompaniment of extensive burns. It is supposed to be due to ecchymosis of the mucous membrane and subsequent erosion. In many cases of fatal burns, however, such ulcers are not found.

The external appearances of the burns vary with the degree. A burn that during life has merely produced erythema may, by reason of the post-mortem distribution of the blood, escape attention after death. If the burn is intense the spot may remain, and forms good evidence of the burn having been produced during life. Even though redness may have vanished, the epidermis may show some change. In burns of the second degree vesicles are produced, serum exuding in the lower layers of the epidermis, and lifting up the horny layer. These vesicles may be small or large, and after death they may remain unbroken, and may be surrounded by an area of hyperæmia, or the latter appearance may be absent. If the vesicle has been broken, and if this has recently occurred, the denuded corium underneath is moist and light in color, and the shrivelled epidermis may still be partly attached. If, however, the part has been exposed to air for a longer time the denuded corium becomes dry, hard, yellowish or yellowish brown, or dark brown in color, and like leather or parchment in consistence. In burns of the third degree involving the corium down to the subcutaneous tissue, if recently produced by scalding, the tissue may be white or grayish white, as if cooked, from coagulation necrosis, or, if produced by a burn, may present the appearance of having been roasted. The vesicle filled with serum is a fairly good indication of a burn having occurred during life. Although some have claimed to have been able to produce such vesicles post mortem, in most of the experiments performed on the cadaver such vesicles contain gas but not serum. When burns of the third degree have occurred during life, the blood in the vessels is immediately coagulated. If a burn is produced post mortem, unless possibly in a dependent portion of the cadaver, the coagulated blood will be found only in the veins and capillaries, and not in the arteries as well. Histological examination of such tissue may, under these circumstances, prove of value. It is said that the network presented post mortem by leathery, dried-out burns, is due to the coagulation of blood in the vessels, and if the burn has been produced during life such a network is very much finer than if the burn is produced after death.

Where complete charring of the skin has been produced in conflagrations spontaneous rupture may occur, its usual site being the flexor aspects of joints and the perineum. Such spontaneous lacerations have been mistaken for wounds. They present, however, no reaction, no hemorrhage, and through the adipose tissue from one surface of the laceration to the other, vessels and nerves may pass. With the charring of the skin, rupture not having as yet occurred, a contracture and shrivelling of the tissue beneath may take place. The charred skin protects the underlying parts from further charring. On this account complete incineration at conflagrations does not usually occur. Besides a bursting of the scalp, fracture of the bone or the formation of holes in the bone with exfoliation of burned bone after charring, or in addition a diastasis of the sutures or an actual fracture of the skull, produced by the vapor from the tissues within the cranium being subjected to a high degree of heat, may occur. Such conditions may be mistaken for the results of inflicted violence. If injury has been sustained during life hemorrhage occurs, or the tissues may become infiltrated with blood as already discussed. If evidence of such reaction is found the injury must have occurred during life. Another valuable criterion is the examination for carbon monoxide hæmoglobin in the blood that has not been exposed externally. The demonstration of carbon monoxide in the blood in internal parts that could not have come in contact with carbon monoxide after death clearly proves that carbon monoxide was inhaled. This test may be of value in determining whether life was extinct or not when the individual was exposed to the smoke.

The question may arise as to the time which must have elapsed before the effects found in charring of the body could have been produced. It has been found that an hour's exposure to flame will cause a complete charring of the soft tissues, and a further hour's exposure to the heat of glowing embers will cause calcining of the bones of a newly born child. At conflagrations the result is probably produced after a much longer exposure. The exact time might be very difficult to determine.

The identification of charred bodies or portions thereof may present great difficulties. The marked shrinkage of the tissues (with the exception of bone), due to prolonged exposure to heat, should be remembered. A case is reported in which a part found consisted of a pelvis, clearly that of a male adult, which was embedded in a mass about the size of a man's head. In it were also found the heart, liver, coils of intestine, and the external genitalia which were very small. The organs presented an appearance that would have led one to estimate the age of the subject as between four and six years. The bones, although completely charred, may still sufficiently sustain their form to be a valuable guide in determining probable age, or, at least, height of the subject, and the pelvis may aid in determining the sex after puberty.

Death from Exposure to Cold.—Appearances due to frost bite may or may not be present. Light red spots of post-mortem decomposition are supposed to be characteristic by some and are denied by others. The heart and central veins have been described as abnormally filled with blood, this being supposed to be due to contracture of the peripheral part of the vascular system. The diagnosis must be made by exclusion, and from the circumstances of the case.

Death from Starvation.—The proof of this may be of medico-legal importance, more especially in cases of children who have been subjected to cruel and inhuman treatment. The blood is markedly anæmic and clotted, and may be quite thick in cases in which the subject has in addition been deprived of water. The heart may be small, soft, and flabby. The liver, spleen, and kidneys may be smaller than is natural, from atrophy. Stomach and small intestine may be empty, and there is a marked diminution of subcutaneous fat and also of internal fat, namely, in the omentum, mesentery, perinephritic tissue, and subpericardial tissue. Fat, however, is never entirely absent. The external appearance of the cadaver presents the characteristic appearance of marked emaciation.

Otto H. Schultze.

AVA. See *Kava*.

AVENS.—Under this name are known various species of the genus *Geum* L. (Fam. *Rosaceæ*), of which there are some thirty or forty, distributed through both temperate zones, especially the northern. By Avens is generally understood the rhizome and root of *G. urbanum* L., while that of *G. rivale* L. is known as Purple Avens, in allusion to the purple flowers of the plant. *G. Virginianum* L. and some others are known as White Avens. None of them is much used at present, but they were formerly largely employed, both in domestic and in professional practice, as astringents and tonics. They contain volatile oils, amaroids, and much tannin. The oil quickly disappears from them in and after drying. The combination of tannin and volatile oil (when fresh or recently dried) gives them a much better control of summer diarrhœas than do drugs which are astringent merely, and this is their proper field of usefulness. They are given in doses of 1 to 4 gm. (ʒ ¼ to 1).

H. H. Rusby.

AVON SULPHUR SPRINGS.—Livingston County, New York.

Post-Office.—Avon. Hotel.

Access.—Branches of the Erie system extend in four directions from Avon, forming direct communication with New York, 367 miles distant, Rochester 18 miles, and Buffalo, 66 miles. The village has a surpassingly beautiful location, nestled as it is in the charming and picturesque valley of the Genesee. The springs are on a somewhat lower level, about three-quarters of a mile from the village. The surrounding country is delightfully interspersed with fine drives, charming lakes, streams, etc. The use of the Avon Springs for medicinal purposes dates from 1792. Those found to possess the greatest efficacy are known as the "Upper" and the "Lower" spring. The "Congress" and the "Magnesia" springs are also used to some extent, the latter being the favorite for drinking. The following analyses show the chemical ingredients in one United States gallon of three of the springs:

Solids.	Upper Spring, J. Hadley, analyst. Grains.	Lower Spring, J. R. Chilton, analyst. Grains.	Congress Hall Spring, H. M. Baker, analyst. Grains.
Calcium carbonate	8.00	29.33	9.25
Sodium sulphate	16.00	13.73	21.02
Calcium sulphate	84.00	57.44	27.61
Magnesium sulphate	10.00	49.61	19.07
Sodium chloride	18.40	....	29.11
Calcium chloride	....	8.41	
Sodium iodide	....	Trace.	
Sodium sulphide, Calcium sulphide	....	....	99.55
Total	136.40	158.52	205.61
Gases.	**Cubic inches.**	**Cubic inches.**	**Cubic inches.**
Sulphureted hydrogen	12.00	10.02	27.63
Carbonic acid	5.60	3.92	22.04
Oxygen	....	0.56	0.97
Nitrogen	....	5.42	3.88
Total	17.60	19.92	54.52

These waters are of the saline-calcic, sulpho-carbonated variety. The chemical constituents of the magnesia spring are believed to be quite similar to those of the lower spring, with, however, a greater proportion of sulphate of magnesia. In consequence of the considerable proportion of this ingredient the two latter springs have valuable laxative and purgative properties. They thus become useful in disorders of the gastro-intestinal tract accompanied by torpor of the liver and constipation. The water also produces an increased activity of the functions of the skin, and free diaphoresis often ensues. The water also possesses antacid properties and has been found of special benefit in cases of dyspepsia attended by flatulence, heart-burn, and gastric catarrh. Both internally and in the form of baths, these waters have been found beneficial in cases of obstinate rheumatism, diseases of the urinary tract, and in various skin disorders. Facilities for all kinds of hot, cold and electric baths are supplied.

James K. Crook.

AXILLA. See *Shoulder*.

AXOCOPAN.—Municipality of Axocopan, State of Puebla, Mexico.

These springs are located in a romantic region surrounded by beautiful and picturesque scenery, about 5 km. east of the city of Atlexco. To the east of the location of the springs is the famous hill of San Miguel, noted for its religious associations. The view to the west is cut off by a succession of hills of volcanic origin, while on the north loom up the magnificent volcanoes of Popocatapetl and Ixtaccihuatl. To the northeast is the volcano of Malintzin, while the blue dome of the tropical sky surmounts the whole. Luxuriant vegetation embracing many varieties of trees and flowers surrounds the location of the springs. The waters of these springs resemble those of Vichy in France. They are naturally cold, perfectly transparent, and have a snappy and piquant sparkle from the presence of carbonic acid gas in great abundance. According to an analysis by Carrasco, the waters contain the bicarbonates of sodium, calcium, magnesium, potassium, and iron, sulphate of sodium, chloride of sodium, silicate of alumina, silicic acid, and a small percentage of organic matter. These waters are said to be exceedingly agreeable to the palate. They stand transportation well and will no doubt eventually find their way into the markets. The location of the springs offers an unusual combination of attractions for the establishment of a popular health resort. Bathing in the open air may here be indulged in throughout the year. The waters are said to be useful in diabetes, lithiasis, gastric disorders, and especially in diseases of the skin.

N. J. Ponce de Léon.

AYAPANA. See *Thoroughwort*.

AYER'S AMHERST MINERAL SPRINGS.—Erie County, New York.

Post-Office.—Williamsville. Hotel.

Access.—The Buffalo and Williamsville trolley line is a mile and a half distant. The springs are four miles, two miles, and four miles respectively from the following railroad stations: the West Shore, the Lehigh Valley, and the New York Central (branch). The springs (two in number) are owned by Mr. A. D. Ayer, and are located in the town of Amherst, two miles northeast of Williamsville and six miles from Buffalo. The principal spring (artesian) was bored about ten years ago. According to a partial qualitative analysis by Herbert M. Hill, Ph.D., Professor of Chemistry and Toxicology at the University of Buffalo, it contains the following ingredients: Calcium sulphate, iron bicarbonate, calcium bicarbonate, magnesium sulphate, sodium chloride.

It is not possible to classify the water from this analysis, but it would appear to be a calcic chalybeate, with sufficient Epsom salts to give it laxative properties. A complete quantitative analysis is desirable.

The water is highly recommended for chronic constipation, sick headache, dyspepsia and gastric catarrh, hemorrhoids, and other conditions due to a disordered state of the gastro-intestinal tract. The building of a sanitarium at the springs is under contemplation.

J. K. Crook.

AZEDARACH.—*Pride of China* (*or of India*). *Chinaberry Tree.* The bark of the root of *Melia Azedarach* L. (fam. *Meliaceæ*). This is a fine, medium-sized, ornamental tree from India, but long cultivated in all the warmer parts of the world. It has delicate, twice pinnated leaves, fragrant clusters of lilac-colored flowers, and yellow globose fruits of the size of small grapes. Azedarach has been occasionally used for one or another purpose in various countries where it grows, and, in deference to a slight reputation in the Southern States was some time ago admitted to the Pharmacopœia. It is now, however, excepting as an extemporary country medicine, nearly obsolete. The bark of the root is thus described: "In curved pieces or quills, varying in size and thickness; outer surface red brown, with irregular, blackish, longitudinal ridges; inner surface whitish or

brownish; longitudinally striate; fracture more or less fibrous; upon transverse section tangentially striate, with yellowish bast fibres; almost inodorous, sweetish, afterward bitter and nauseous."

It contains a whitish-yellow resin, which is claimed to be the active principle.

Azedarach disturbs the digestive tract, causing, in large doses, vomiting and diarrhœa. It is a fatal narcotic poison in still larger ones, but its qualities are not well known. It is usually given, however, for intestinal worms, in decoction, or in syrup of the fresh root. Dose, 4 to 8 gm. (℥i. ad ℥ij.).

Birds become stupefied by eating the berries, and fatal cases of poisoning by the seeds have occurred in India.

ALLIED PLANTS.—*Melia Indica* Brandis. *Margosa*, another Indian plant of the genus, has a bitter bark and wood. It is used as a tonic. *W. P. Bolles.*

AZORES.—The Azores or Western Islands lie about 2,000 miles from Boston, 1,400 miles from the Lizard Point, in England, and 800 from the coast of Portugal, of which they are a possession. The islands are nine in number and are divided into three distinct groups, about one hundred miles apart: Santa Maria and San Miguel forming the southeastern portion, Flores and Corvo the northwestern, and the remaining five the central division. The total area of the islands is about 1,000 square miles, and the population is estimated at 300,000. San Miguel is the largest island, being 40 miles long and 10 broad. Fayal and San Miguel are the two islands which are generally visited and with which there is the best communication. One can reach them by steamers from New York and Portugal, and possibly by sailing vessels from Boston. The whole system of islands is of volcanic origin, and their outlines in consequence are rugged and picturesque. The coast line is precipitous, and the central portion of each island rises in mountain peaks, which vary in height from 1,889 feet (San Miguel) to 7,613 feet (island of Pico). There are no natural harbors, and vessels lie in the open roadstead off the principal ports. A breakwater has been under construction for a long time at San Miguel, but it is not yet completed.

The vegetation is rich and luxuriant, and both tropical and subtropical fruits—the fig, orange, banana, loquot, pineapple, prickly pear, guava, pomegranate, and lemon—grow in the open air. Flowers bloom in nearly infinite variety, and the gardens of San Miguel and Fayal contain an almost endless diversity of tree, flower, and fruit. There are no fewer than forty plants peculiar to the islands. Besides these there are about four hundred species which are found in Europe, and three hundred and forty which are not found in Europe, but are common to Madeira, the Canary Islands, and the Azores (Roundell).

The climate is a mild and moist marine one, and very equable at all seasons of the year. The mean annual temperature is 62° F. The extremes are stated to be 86° and 45° F. The range between winter and summer is from 10° to 15°. The night temperature is generally not more than four degrees cooler than the day. The summer is enervating at 70° F., and one is drenched with perspiration on the slightest exertion. The mean temperature for winter is 58°, for spring 61°, for summer 68°, and for autumn 62° F. The three coldest months are usually January, February, and March. In winter it sometimes feels chilly and damp, and one seldom leaves home without an umbrella. The humidity is so great that wall-paper will not adhere, and the veneering of furniture strips off. The mean annual relative humidity is 76 per cent. and for winter it is 77 per cent. The mean annual rainfall is 38.5 inches. The wind blows with great force at times and there are frequent storms. "The prevailing direction of the wind in winter is from the south, south-west, and northwest, and in summer from the northeast, east, and north" (Solly, "Medical Climatology," 1897).

Ponta Delgada, in San Miguel, is the largest city of the islands. It has a population of 25,000 inhabitants. There is a good theatre, a public library, numbers of fine gardens, ancient churches and government buildings, public markets, etc. There are comfortable accommodations here as well as at Horta, the principal town of Fayal, and the food is generally good. Twenty-seven miles from Ponta Delgada by carriage road, through beautiful and wild scenery, is the Valle das Furnas, where are hot sulphur springs of a temperature of from 56° to 212° F. All contain sulphur, iron, alum, and silica in varying proportions. Besides the public bath houses, built by the Government and free to all, there are also private baths. The bath tubs are cut out of solid limestone or lava rock, and have taps for hot and cold water, the hot coming from the sulphur spring, and the cold from the water impregnated with iron. The bathing season begins in June and lasts for six months, during which time a large number of people frequent Las Furnas. The general custom is to hire lodgings and to take meals at the hotels. The various diseases for which these springs are beneficial are chronic rheumatism, which is almost invariably benefited; paralysis, syphilis, skin diseases (especially eczema), dyspepsia, and internal troubles.

Las Furnas itself is situated in the valley of the Furnas, which is the bottom of a vast crater of an extinct volcano. In this valley are the various boiling springs, with masses of white vapor hanging over them. A roaring noise is heard, as the hot gases issue from the earth. The *Caldeira Grande* supplies the sulphur water to the baths, and is enclosed by a wall some six feet in height. The water in this tank-like enclosure boils in a most furious manner and with a great noise. It furnishes nineteen gallons per minute (Roundell). The ground about is covered with patches of white sulphur and alum, streaked with orange and red. In another part of the valley is the *Boca do Inferno*, or "Mouth of Hell," a dark pit of unknown depth filled with boiling mud, constantly thrown up with a great smoke and noise. This mud is collected by the people and used as an external application in skin diseases. All the geysers or springs are said to boil most furiously when the wind is east.

So far as the climate in general of these islands is concerned it is applicable to such cases as require a mild, equable, moist climate. It is therefore suitable for patients who are suffering from neurasthenia, from Bright's disease, from nervous affections, from hay fever, etc., and for those who are convalescing from the grippe and from other acute diseases. "There is comparatively little sickness on any of the islands—very rarely any regular fevers or epidemics of any kind prevail" (Junkin). The water supply is from springs, wells, and cisterns, and is generally good.

From a personal visit to Fayal and Pico, the writer can testify to the charm and fascination of these strange islands with their ancient and primitive customs, beautiful scenery, and delightful and ever-varied walks, drives, and excursions. One can hardly conceive of a more entrancing place for the lover of nature, or one more restful and refreshing for the weary and overworked. The only drawback is the long journey there, which is almost prohibitory to a sufferer from sea-sickness.

For a very interesting and extended account of these islands the reader is referred to Mrs. Charles Roundell's "A Visit to the Azores," and also to the two papers by Canfield and Junkin on "The Azores as a Health Resort."

Edward O. Otis.

AZULE SPRINGS.—Santa Clara County, California. Location, 12 miles west of San José. These springs are not in use as a resort, but the waters are bottled and shipped in large quantities to all parts of California and even more distant points. An analysis by a chemist whose name we have been unable to secure resulted as follows:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	86.73
Sodium carbonate	52.19
Potassium chloride	10.90

Solids.	Grains.
Potassium carbonate	2.85
Magnesium carbonate	78.16
Magnesium chloride	17.42
Calcium carbonate	10.05
Silica	3.20
Organic matter	0.18
Total	261.68

Free carbonic acid gas, 153.77 cubic inches; temperature, 59.6° F.

This is a good example of the alkaline-saline-carbonated class of waters. The analysis shows considerable resemblance to that of the Nassau Seltzer Springs in Germany. The water possesses antacid, aperient, diuretic, and tonic properties. *J. K. Crook.*

BACTERIA, PATHOGENIC, AND OTHER PATHOGENIC MICRO-ORGANISMS.

THE SCHIZOMYCETES OR BACTERIA.

These are the smallest and at the same time the most interesting of all known living organisms. While most bacteria are harmless—some of them, indeed, being of the greatest use in the economy of nature, by producing the decomposition of dead animal and vegetable matter, without which life on the earth would be impossible—others are the cause of various infectious diseases in man and animals. Bacteria are very widely distributed in nature, and are present in the air, water, soil, and also in the food and bodies of animals.

HISTORICAL REVIEW OF THE DEVELOPMENT OF BACTERIOLOGY.—Although most of the important discoveries of bacteria in their relation to disease are of comparatively recent date, from the earliest days of medicine, and long before these micro-organisms were known to exist, minute living germs were thought to be concerned in the production of many diseases. Before entering, therefore, into a detailed consideration of pathogenic bacteria, it may be interesting and instructive to review briefly the more important steps which lead up to the development of bacteriology as a science.

The first authentic observations of living micro-organisms of which there is any record are those of Athanasius Kircher, a Jesuit priest, in 1671. The compound microscope dates from 1590, but this observer was the first to find in putrid meat, milk, vinegar, cheese, etc., minute living organisms or "worms," invisible to the naked eye, which he concluded must be the cause of putrefaction. Kircher, however, did not describe the form or character of these "little worms," and with the microscopes in use in his day he probably did not see bacteria, as we now understand them. Nevertheless, his observations seemed to substantiate the view that infective diseases might be caused by substances which, introduced into the body, give rise at first to no symptoms but increase till they bring about disease: the opinion held at that time by many physicians being that if putrefaction is produced by living organisms outside the body, when these organisms are found in the blood, etc., they must necessarily cause putrefaction there also.

Not long after this, in 1675, Anthony van Leeuwenhock, a citizen of Delft, Holland, a linen draper by trade, who practised the art of grinding and polishing lenses, constructed a microscope with which he was able to observe in rain water, in putrid infusions, in human saliva, in intestinal evacuations of man and animals, and in the scrapings between the teeth, numbers of living "animalcula," as he called them, varying in form and size and in the character of their motion. Of these he gave descriptions and drawings which are remarkable for their accuracy, considering the imperfect optical instruments at his command, and there is little doubt that he really saw some of the larger species of bacteria, probably spirilla. Leeuwenhock made no attempt to assign any importance to these organisms regarding any rôle they might play in relation to disease, his work being conspicuous for its purely objective and unspeculative nature. But his contemporaries and those who immediately succeeded him seized upon the idea of these animalcules causing a great number of diseases, even in cases in which they were not found, reasoning from analogy that they must be present, until there arose a veritable craze of the germ theory of disease or *contagium animatum*. Then later followed a reaction, and the idea for a time was ridiculed out of existence. And so throughout the history of medicine this theory continued to be often asserted and as often again denied, on speculative grounds, until well into the present century, when the question was finally settled by actual observation and experiment.

Among those who at this early date (the end of the sixteenth and beginning of the seventeenth century) held to the doctrine of *contagium animatum* were Lange and Hauptmann, who shortly after Leeuwenhock's investigations advanced the opinion that puerperal fever, measles, smallpox, typhus, pleurisy, epilepsy, gout, and many other diseases were due to animal contagion. And in 1701 Andry and Linné assumed the same origin for syphilis, and Lancisi (1718) for malaria. Antonius Plenciz, a physician of Vienna, who published his deductions in 1762, maintained that not only were all infectious diseases due to micro-organisms, but that the infective material could be nothing else than living animals or plants. On these grounds he endeavored to explain the variations in the incubation period of different diseases. He insisted also that special germs were concerned in the production of each infectious disease. Plenciz believed, moreover, that these micro-organisms were capable of multiplication in the body, and suggested the possibility of their being conveyed from place to place through the air, etc. Besides these deductions he also made original investigations into the processes of putrefaction and fermentation, and having found animalcules in all decomposing material, he became so thoroughly convinced of their causative relation to these processes that he formulated the law that decomposition of animal and vegetable matter takes place only by means of and through the increase of living organisms.

Still all this was entirely a matter of speculation only, unproved by direct experiment; but the theory advanced was so plausible and the arguments used in its support were so logical and convincing, that in spite of great opposition and ridicule it continued to gain ground, and in many instances the conclusions reached by these early philosophers have since been shown to be correct.

Meanwhile the question which most attracted the interest of all investigators into the cause of infectious diseases was: What is the source of the micro-organisms which are supposed to produce these processes? Are they the result of vegetative changes in the substances in which they are found—the theory of *generatio æquivoca*, or spontaneous generation; or are they reproduced from similar pre-existing organisms—the vitalistic theory? This question is intimately connected with the investigations into the origin and nature of fermentation and putrefaction, for it was in these experiments that the theory of spontaneous generation was overthrown and the germ theory established.

Of those who most vigorously advocated the idea of *generatio æquivoca* was Needham, who, in 1749, attempted to prove experimentally the truth of his opinions. He placed a grain of barley in a watch glass containing water, covered it carefully, and allowed it to germinate. On later examination he found living micro-organisms present which he maintained were the effect, not the cause, of the decomposition and due to vegetative changes in the grain itself. Again, he boiled meat infusions and kept them in tightly corked flasks; in these also living organisms developed. As all life must have been destroyed by the boiling, and the closed flasks shut out apparently everything from without, Needham concluded that the organisms present could have been produced only from the dead material by spontaneous generation.

This conclusion seemed indeed irrefutable at the time, but Bonnet, in 1762, suggested that possibly there were certain germs which were able to resist the boiling temperature, or that the flasks were not so tightly closed that no germs could enter. Then in 1769 Lazarus and Spal-