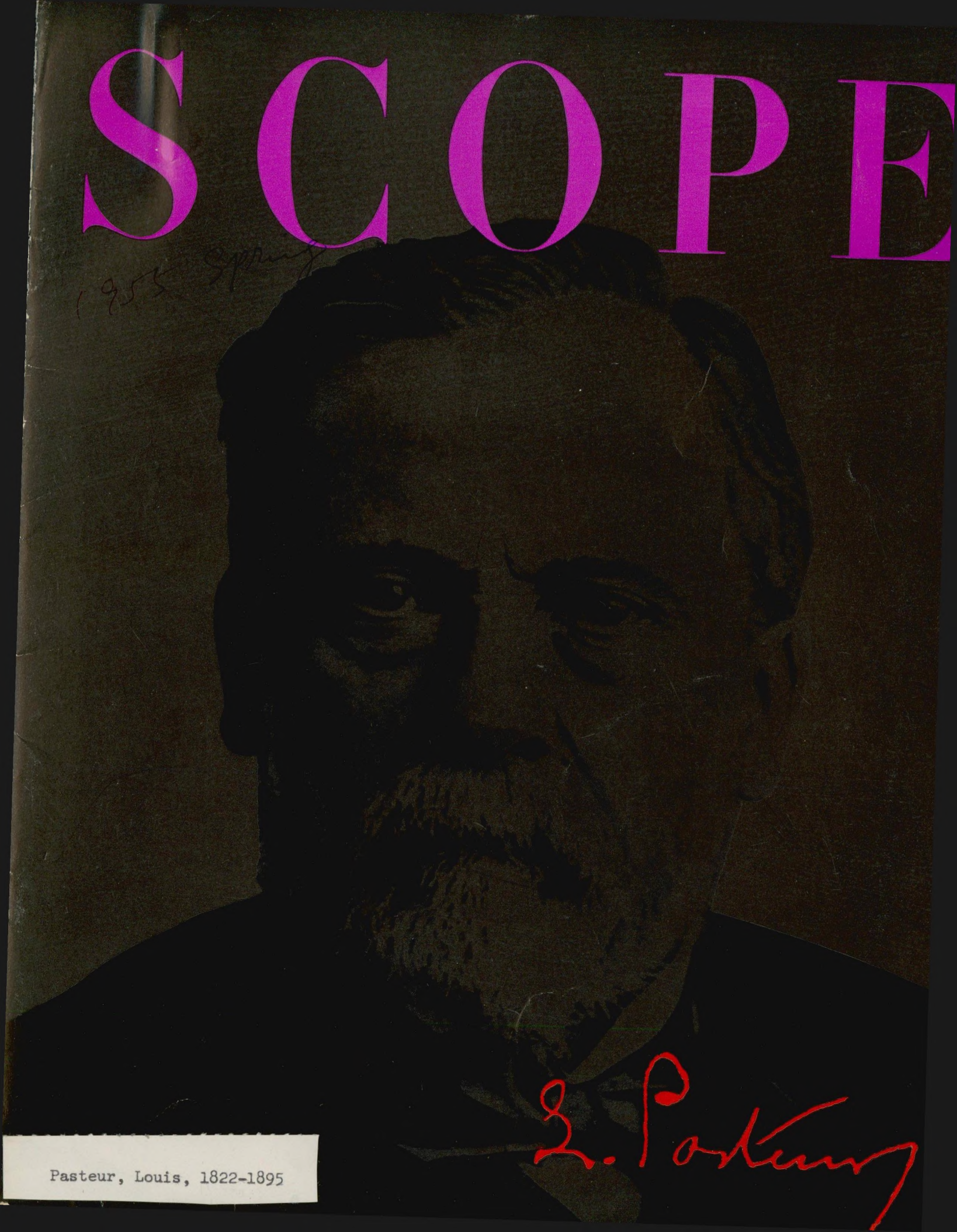
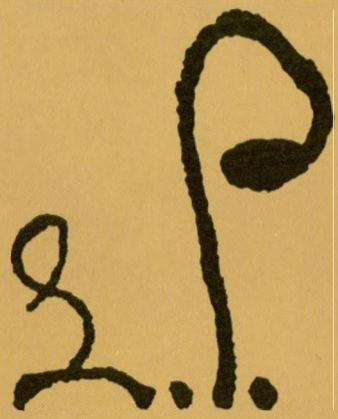
SCOPE

1955 Spring



Pasteur, Louis, 1822-1895



Louis Pasteur—Contemplation of the events in the life of a man of genius can be of great interest and may also give valuable insight into subjects with which he has been concerned. By far the most interesting part of Pasteur's life is his work.

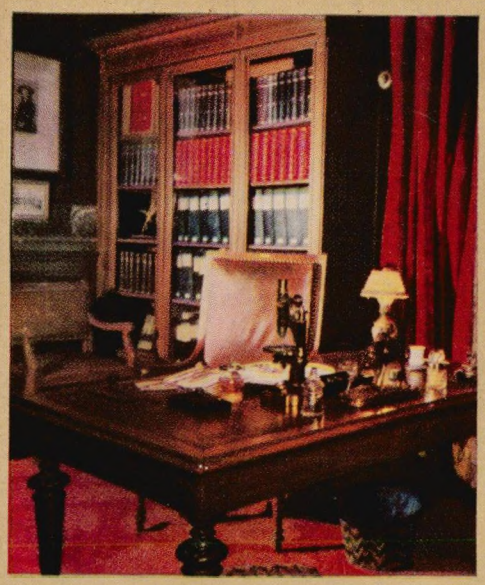
PASTEUR's earliest recorded works are not scientific memoirs but portraits of his parents and friends in Arbois, all of which he made in his teens when painting was his favorite pastime. The pastel portrait of his mother, in fact, was done when he was only 13 and that of his father, one of his latest, at 19. These early paintings show that young Pasteur had remarkable ability as an artist. While the pastels suffer considerable loss in reproduction, even a casual glance indicates that they are rather remarkable not only in the mechanics of depiction but in their complete lack of the insipid prettiness that characterized much of the contemporary portraiture. Rather they partake of the stark realism and virility characteristic of the early Renaissance. Albert Edelfeldt, who painted the well known portrait of Pasteur, put it succinctly in a letter to a friend: ". . . some of these pastels are in his home at the Institute and I have looked at them very often. They are extremely good and drawn with energy, full of character, a little dry in color, but far superior to the usual work of young people who destine themselves to an artistic career. There is something of the great analyst in these portraits: they express absolute truth and uncommon will power. I am certain that had M. Pasteur selected art instead of science, France would count today one more able painter. . ." Apart from aesthetic considerations, these portraits reveal two outstanding qualities which characterize all of Pasteur's later works and account for much of his success: unusual technical ability and keen and accurate observation. It was the observation of a slight discoloration of the soil in a field where a sheep that died of anthrax had been buried that led to the discovery of the part played by earthworms in the spread of this disease.

Why Pasteur gave up art and devoted himself to science is not clear. Certainly it was no emotional upheaval such as popular biographers and novelists delight in; his personal life seems to have been normal and tranquil. It is more likely that he wished to come to closer grips with nature (the world as we find it) than appeared possible in the field of art in his day. The age in which Pasteur lived—the middle and late Nineteenth Century—was a period when the arts decayed while the sciences made unprecedented progress. It is perhaps not surprising, therefore, that even a young man with unusual artistic ability should turn from art to science. It is clear though perhaps not widely realized that the gap between art and science is more apparent than real; the artist and scientist both seek to understand and interpret nature. The artist is as much a discoverer of natural harmonies as a creator, and the scientist without creative ability is little more than a not too reliable recording instrument. In turning from art to science Pasteur was perhaps merely furnishing his lively and creative imagination with another medium of expression. Nevertheless, his ability to make a clear and dramatic visual demonstration of a natural phenomenon which remained with him throughout life undoubtedly contributed in no small part to his ultimate success.

Pasteur's portrait of his father

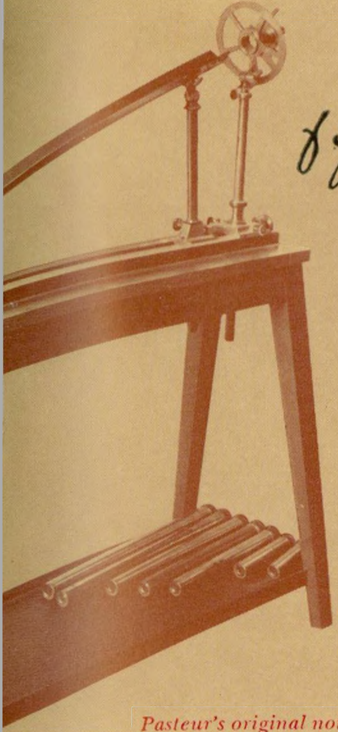
Pasteur's portrait of his mother

It is tempting to speculate that the appeal of the beauty of crystal form to the erstwhile artist's eye may have influenced Pasteur's choosing the field of crystallography for his first major research. It is more probable that his association with men already interested in this new and rapidly advancing field had a greater influence. He apparently undertook the study of the tartrates with no idea of making an original contribution, but only to perfect his knowledge of crystallographic techniques. Pasteur seems to have been fascinated by the discoveries being made which seemed to indicate a relation between crystal form, effect on the beam of polarized light and molecular structure. Then Mitscherlich observed that paratartrates although having the same crystal form as the tartrates did not rotate the beam of polarized light. Pasteur sensed an inconsistency in this seeming lack of relationship between crystalline form and optical rotation and painstakingly set about finding it. First, asymmetric crystal faces in the tartrates which had escaped previous observation were revealed. He then examined salts of paratartaric (racemic) acid, convinced that since solutions of salts of this acid did not affect polarized light, the asymmetric faces would not be present. He was disappointed; the faces were there. Still persisting, however, he discovered that there were two types of crystals, one with asymmetric faces to the right and one with similar faces to the left. After manual separation of the two types of crystals, the demonstration that each of these when dissolved rotated the beam of polarized light in the opposite direction and so when mixed would neutralize each other completed the great discovery which was to provide the basis for applying physical methods to the study of molecular structure. Biot was so impressed by the experiment's importance that he had Pasteur repeat it in his presence. When Biot read the polarimeter, he realized at once that Pasteur's discovery was indeed correct, and the great physicist was deeply moved. The instrument used in this demonstration is pictured above.



Pasteur's study at the Pasteur Institute

Pasteur dictating notes on silkworm disease to his wife (1868)



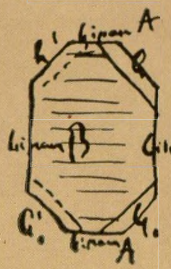


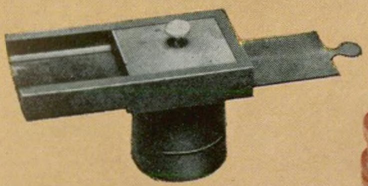
fig 1

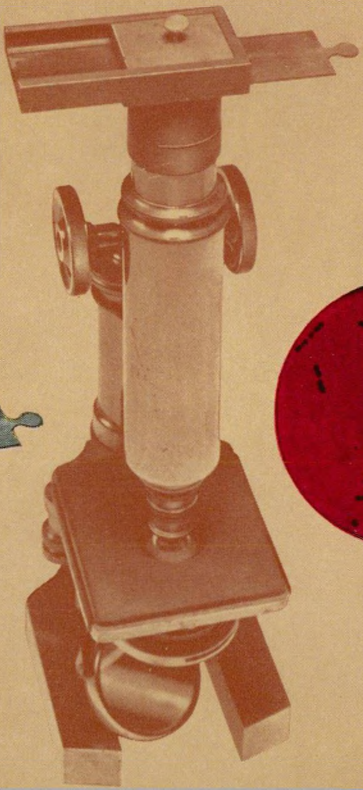
Voici la forme de ces lames : les faces h' h, h' sont des faces tétraédriques. Mais, [illegible] deux faces avec la face du biseau A ne sont pas d'[illegible] normales aux arêtes des biseaux comme cela arrive dans le bitartrate pur. Je crois que cela est vrai pour le biseau B, mais cela m'est moins net. Il faut noter que dans le bit. pur le clivage est vertical et perpend. à l'arête du biseau [illegible] net. Dans la figure ci-contre c'est dans le biseau B qui [illegible] véritable biseau [illegible] en se laissant guider par le clivage.

Pasteur's original notes on the asymmetric structure of tartaric acid, and polarimeter used by Biot to confirm this great discovery.

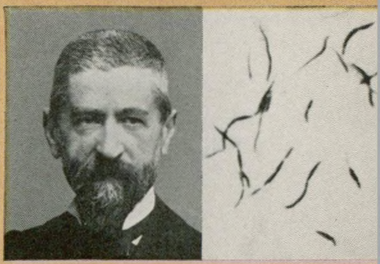
To Pasteur the greatest significance of his discovery was that it indicated the asymmetry of the tartaric acid molecule. This asymmetry of molecular structure Pasteur believed characterized the organic substances as distinguished from the inorganic. This idea became a guiding principle throughout all his subsequent work and was to a considerable extent concerned with his transferring his attention from chemistry to microbiology. The transition was made through the study of fermentation, the chemistry of which was engaging the attention of many of the prominent chemists of the day. Pasteur had made such observations as disappearance of only the dextrorotatory tartrates from mold-contaminated solutions containing both dextro- and levorotatory forms in equal concentration. He therefore believed that fermentations took place only through the instrumentality of microorganisms.

It was generally believed at the time that fermentation arose spontaneously in suitable organic matter and that the microorganisms that were demonstrated in such material were spontaneously generated. Pasteur thus became involved in the controversy concerning the nature of fermentation and also in the controversy over spontaneous generation of life, because if microorganisms arose spontaneously in fermenting material they could scarcely be the primary cause of the reaction. He was, of course, not the first to question spontaneous generation of life, but it was he who gave it the *coup de grâce*. He prevailed in the other controversy also in that no one during his lifetime was able to demonstrate a fermentation taking place in the absence of microorganisms. In the light of our present knowledge, however, his opponents were to a certain extent right also, for we now know that the enzymes that perform these reactions can be extracted from the living cell and will perform their function in its absence. Pasteur not only demonstrated that fermentation does not take place in the absence of living organisms even if oxygen is available, but also that in the presence of microorganisms it can occur in the absence of gaseous oxygen by the transfer of oxygen

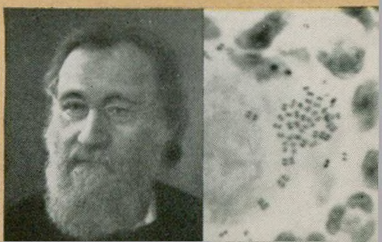


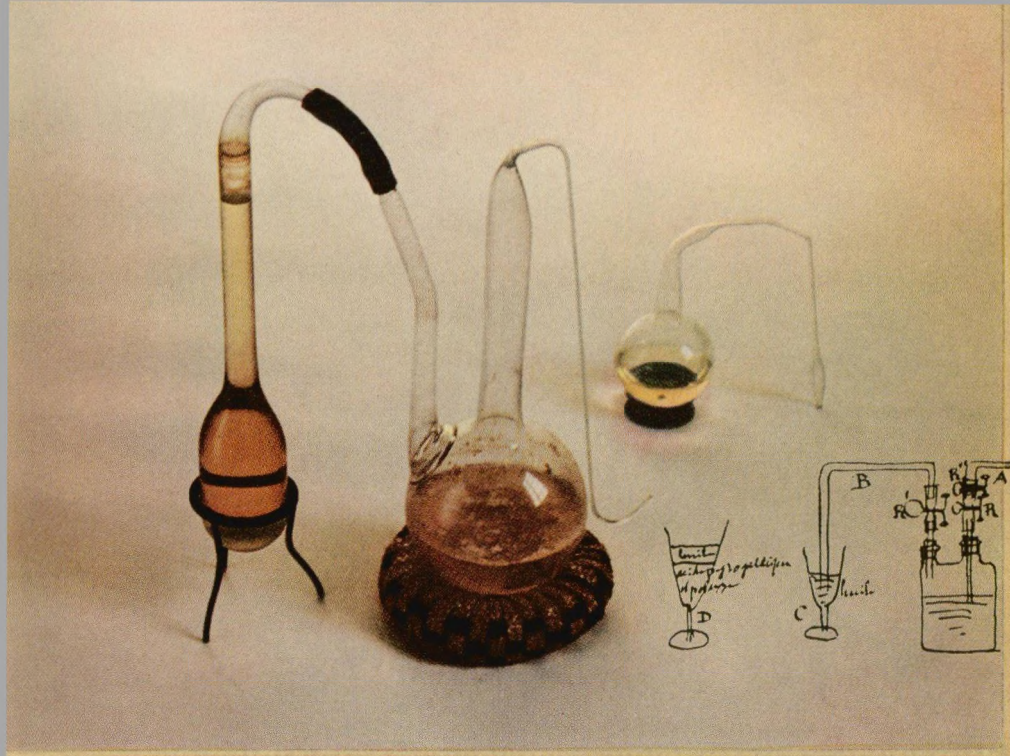


One of Pasteur's last microscopes with photomicrographic attachment, invented by Roux, mounted on the eyepiece. Plate is exposed by slide on right and removed by sliding block to left. The early photomicrograph of lactic bacilli (left) was made with this apparatus.



EMILE ROUX, *who collaborated with Pasteur from 1877 until the latter's death, directed the development of antidiphtheria serum (early photomicrograph of Corynebacterium diphtheriae). Director of the Pasteur Institute from 1904 to 1933.* →



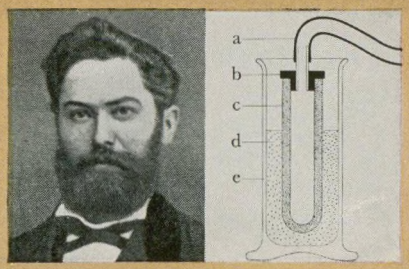


Pasteur's double flask for demonstrating anaerobic fermentation, and notes on the subject. In background, flask of barley water prepared and pasteurized by Pasteur in 1860. It was protected from dust but not from air by its long neck. It is still sterile and unfermented.

from one organic compound to another (*see flasks above*). Pasteur's studies on fermentation are one of the great pioneer works on metabolic chemistry and outline the course of both aerobic and anaerobic oxidation by cells. It is curious that this theoretically important biochemistry is to be found in the treatises on wine and beer making. This is because Pasteur was keenly aware of the importance both to the scientist and to the public of applying the latest theoretical knowledge in finding practical solutions to current industrial problems which he could do because of his thorough grasp of manufacturing processes. The process which bears his name, pasteurization, grew out of his work on brewing.

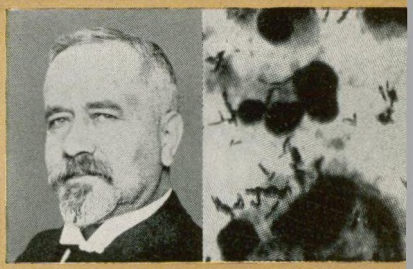
Pasteur was quick to recognize the similarity of the fermentation and destruction of vegetable matter by microorganisms and certain "putrid" diseases in animals and men and enunciated the germ theory of infectious diseases long before he had any actual experience with experimental pathology. His first direct contact with this field came when he undertook the study of a disease of silkworms that was threatening the existence of the silk industry in France. This turned out to be a very difficult problem because not one, but two quite different diseases were involved, which occurred either separately, together or seriatim. While after a great deal of work he arrived at a satisfactory practical solution of the problem, some aspects of the diseases are still not completely understood. From infectious disease of silkworms to infectious disease of animals and men, the field of his most important discoveries, was but a natural step in the logical progress characterizing Pasteur's career.

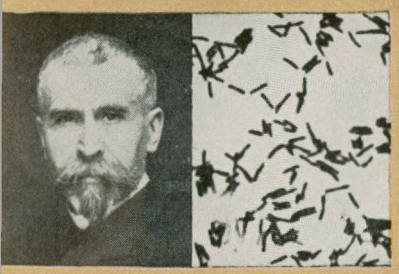
Pasteur from his earliest years always commanded the respect of his teachers and colleagues by his industry and thoroughness. Early in life he made and kept influential friends whose good offices did much in getting him established in his scientific career. In the choice of assistants and associates he also seems to have done well because many of these men contributed much to science in their own rights.



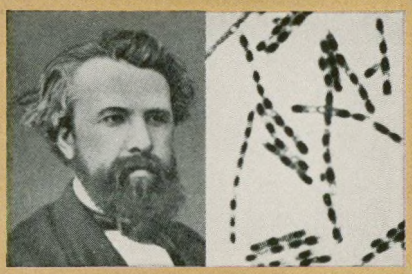
← EMILE DUCLAUX, *Pasteur's early assistant in fermentation and microbiological research. Second director of the Pasteur Institute (1895-1904). Photomicrograph of lactobacilli.*

← CHARLES CHAMBERLAND, *an early co-worker in Pasteur's laboratory on anthrax, fowl cholera, and human infections. He invented the Chamberland porcelain bacterial filter.*





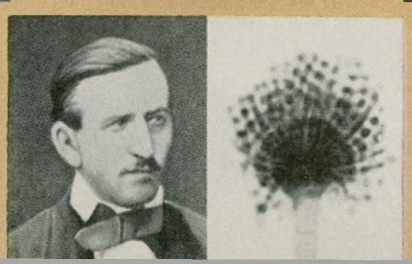
JULES JOUBERT, *who with Pasteur did the famous experiments in which anthrax bacilli, carried through several hundred generations, were still pathogenic (early photomicrograph of this organism).* →



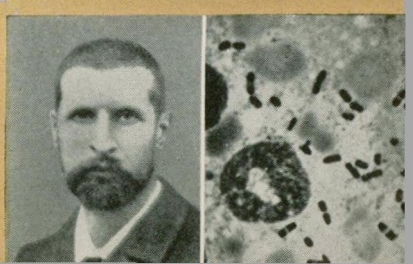
↑ ALBERT CALMETTE, *trained with Pasteur, discovered BCG antituberculosis vaccination at Lille Institute.*

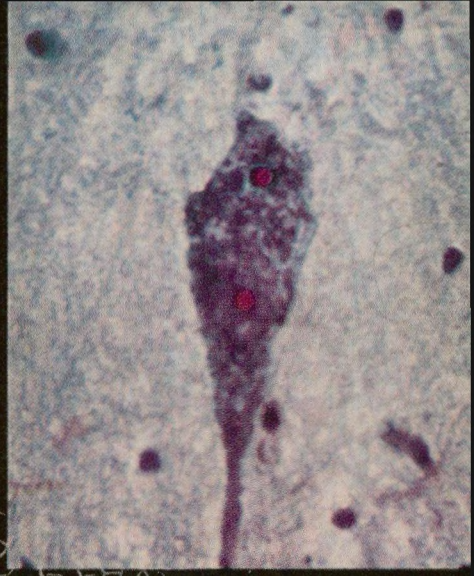
↓ ALEXANDRE YERSIN *in 1894 discovered Pasteurella pestis (rt.), the last pathogen Pasteur saw.*

← ELIE METCHNIKOFF, *one of the first foreigners to join the Pasteur Institute, described phagocytosis, and stimulated the production of serums, vaccines and antitoxins.*



← JULES RAULIN, *Pasteur's first official assistant, did important work on Aspergillus niger; was on the silkworm disease team with Duclaux, Guernez, and Pasteur.*

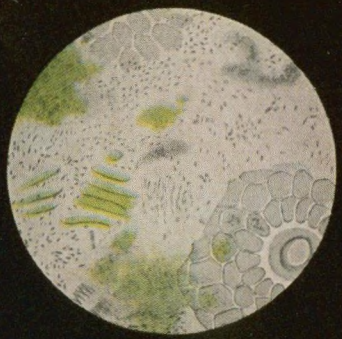




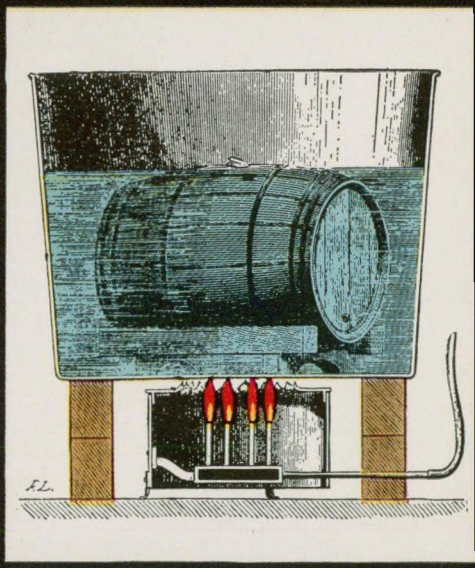
Negri bodies in brain cells

Pasteur felt it his duty to devote himself to important practical problems when called upon. In working with the "diseases" of wine and beer, he devised the process that today is known as pasteurization. In dealing with a disease of silkworms, Pasteur had his first experience in experimental pathology. What at first appeared to be one disease turned out to be two, one protozoal (corpuscular) and one bacterial. Later his monumental work on rabies made him a pioneer in virology.

Dissected silkworm chrysalis

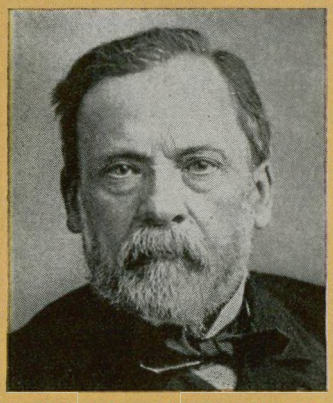


Corpuscles in silkworm disease



In his book on Pasteur, René Dubos entitles the introductory chapter "The Wonderful Century" as indeed the 19th was for science. During this century science for the first time assumed a position of primary importance in Western European thought, and for first time extensive practical applications of it were made. Pasteur epitomized both trends; he contributed much that was new and original in concept and method to theoretical science and also to solving the purely practical problems of his age. To him there was no schism between pure and applied science but, as he said, there was only science and applications of science. He seems to have felt a deep duty to be useful and to have realized that the successful practical application of a scientific idea may be an important demonstration of its truth. Furthermore, in the course of solving practical problems, not a few important theoretical matters come to light.

Pasteur's career illustrates how an important principle hit upon early in life and followed to its logical conclusion may lead a man to make many important theoretical and practical discoveries. Though the principle of asymmetry as an inherent and characteristic property of life was known to all through his pronouncement, it was a great creative force only to him who had the breadth of knowledge and imagination to use it. It would seem to have been a concept for which Pasteur found various definite expressions in specific instances but for which in its most general form he had only an intuitive feeling. Early, he felt he might find a means to exert on suitable chemicals an "asymmetric force" of sufficient strength to create life, and he experimented to this end. Later, as he better understood the complexities of the problem, he ceased these attempts. It is no mean compliment to the man's great intellectual honesty that this opponent of spontaneous generation of life should have always harbored the hope that under suitable circumstances life could be generated from dead matter.



LOUIS PASTEUR

Pasteur seemed to feel that his career followed an inevitable logic, and it is easy to see a logical pattern in his work; asymmetric crystals led to fermentation which led to microorganisms and thence to disease. Nevertheless, as Dubos points out, this logic was not inevitable. He cites examples of various alternate courses Pasteur's work might easily have taken based on subjects Pasteur discussed but did not pursue, although he appeared to realize their importance. In later life he regretted that he had had to leave so many leads undeveloped.

Pasteur's correct concept of the asymmetric molecular structure of organic compounds could easily have led him to develop the concepts of stereoisomerism which was later done by others. His knowledge of the different effect of dextro and levo compounds on living organisms could have led to important pharmacologic and biochemical principles. Having established the germ theory of fermentation, he realized that one can find in nature microorganisms capable of performing almost any organic reaction. Pasteur stated, "A day will come, I am convinced, when microorganisms will be utilized in certain industrial operations on account of their ability to attack organic matter." Most remarkable of all, he recognized that certain common soil microorganisms could render anthrax bacillus incapable of producing disease and speculated that this phenomenon might be used therapeutically. With his knowledge of both microbiology and chemistry, had he found time to return and follow this lead, antibiotic might have been born nearly three-quarters century earlier!

Many such undeveloped speculations attest the fertility of Pasteur's scientific imagination. While no scientist was ever more careful to limit his conclusions to those fully justified by his experiments, Pasteur's working hypotheses in the early stages of an investigation often partook of the fantastic. He himself has said:

"Preconceived ideas are like searchlights which illumine the path of the experimenter and serve him as a guide to interrogate nature. They become a danger only if he transforms them into fixed ideas—this is why I should like to see these profound words inscribed on the threshold of all the temples of science: 'The greatest derangement of the mind is to believe in something because one wishes it to be so'. . .

"The great art consists in devising decisive experiments, leaving no place to the imagination of the observer. Imagination is needed to give wings to thought at the beginning of experimental investigations on any given subject. When, however, the time has come to conclude, and to interpret the facts derived from observations, imagination must submit to the factual results of the experiments."

In addition to the important aspects of Pasteur's character revealed in his work, he appears to have been ambitious and to have enjoyed his success to the fullest. Apparently a man capable of deep affection, he seems to have lived a happy and tranquil private life despite more than an ordinary share of family tragedies. Although not at all concerned with the formalities of religion, he seems not to have been atheistic and often argued against the then popular positivist philosophy. He firmly held that the experimental approach was not suitable for investigating human emotions and religion.