PASTEUR

KNIGHT OF THE LABORATORY

FRANCIS E. BENZ

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BY

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Chapter I Off to Paris

Impatiently the horses pawed, rattled their harness, shook their heads in the driving cloud of rain and sleet. Inside the stagecoach, passengers shivered, chilled to the marrow with the damp, October cold. The driver stomped up and down before the Hôtel de la Poste, now soothing the anxious team, now hurrying the porters who strapped the luggage on board.

On the driver's box—there was no room inside—two boys about fifteen years old huddled under a tarpaulin, trying their best to keep dry and yet wave and talk to their parents who called from under the eaves of the hotel.

One boy smiled as if smiles had always been easy for him, as if he'd never had a care in the world. This happy-go-lucky fellow was Jules Vercel, traveling with Louis Pasteur from their native Arbois to school in Paris.

Though Louis was not the easygoing type, a stranger could have seen he was a real boy. Any of the townspeople of Arbois would have agreed to that. Louis might take his studies a little more seriously than Jules, but he was equally thorough when it came to fishing in the river Cuisance or to the mock battles they staged in the tanyard of Louis' father.

Right at this moment, Louis Pasteur realized he was going to be homesick. And after that, more homesick. The biting, icy rain clattering on the canvas and nipping at his cheeks was bad enough, but looking around him, realizing he would be traveling for two days from this familiar scene was far worse.

The driver blew his horn. The team gave a preliminary jerk at the coach.

"Good-by, Mother and Father," cried Louis.

“We’ll be back for Christmas, don’t forget,” yelled Jules.

“Good-by, Louis! Good-by, Jules! Write as soon as you reach Paris,” cried the parents, almost in concert.

“Keep yourselves bundled up good,” added Louis’ mother as the coach started on its journey.

Lurching through the mud puddles, the great coach pulled away. Fighting to keep back the tears, Louis watched the square towers of Arbois and lastly the steeple of his church, in which he had so often attended services, fade into the whipping curtain of sleet and rain. Even the wonders of Paris, his opportunity for an education there, were not enough to silence that aching sense of loss.

Perhaps Louis felt that way at fifteen when boys of our days would not because, in 1838, a good share of a boy’s life was his home life. Moreover, if Louis had stopped to look into the cause of his lonesomeness, he would probably have seen that his parents took even more interest in his future, in his education, than did those of most of the other boys in Arbois. In 1838 a high-school and a college education was only an unfulfilled dream for most boys. Few of the lower classes, especially, had this opportunity. The majority were called into military service or to work just as soon as they were able to carry a musket or swing a hammer. It had been that way for Louis’ father.

Jean Joseph Pasteur, in fact, had followed both the wars and a trade. The trade he had learned was that of his father, grandfather and great-grandfather, tanning hides and skins. He had barely passed his apprenticeship in the tanner’s field when he had been called to serve in the army. Still in his teens, he had fought with the French Army in Spain, in the Peninsular War, during 1812 and 1813. He was one of the bravest men in the brave Third Regiment and because of his courage advanced quickly to the rank of Sergeant-Major and was finally decorated with the Cross of the Legion of Honor by his beloved leader, Napoleon.

As is the case after many a war, it was hard for these soldiers to return from action and adventure to tiresome trades and police supervision in their native villages. For Jean Pasteur, still under twenty-five years old, life had seemed to settle under a dull cloud. The return of Napoleon from Elba was a faint ray of hope that, when it faded, made work in the tanyard at Besançon even more irksome, more discouraging.

With this uninteresting life, Jean Pasteur began to live more and more within himself. His experiences as a soldier had taught him not to whine, not to cry out, no matter how great his injury. They had taught him caution, not to show his emotions, taught him how much he could gain by controlling his facial muscles. Now in Besançon, faced with the problem of hammering out a living, he grew into a steady, quiet, plodding type of man. In the little church at Besançon, however, Pasteur spent many an hour. He loved to go there in the quiet of the evening and pour out his troubles to his God enthroned upon the altar.

He always felt better, he said, after such a visit.

Only once did he allow his emotions to gain the upper hand and that was when an edict issued by the Mayor of Salins ordered all the late soldiers of Napoleon to turn in their swords to a certain place. Pasteur obeyed this order very reluctantly. One day he heard that these weapons were destined for police service and when he recognized his own Sergeant-Major's saber on a police agent, he could restrain himself no longer. He sprang upon the agent, knocked him down and tore the sword away from him. This action caused quite a commotion in the town. Those on the side of the mayor became very indignant while the former friends and soldiers of Napoleon could hardly restrain their enthusiasm. The mayor was nonplussed. He did not know what to do. He thought that if he punished Pasteur, he would arouse the anger and the ire of the old soldiers of Napoleon who were Pasteur's friends. So he went to the colonel of a regiment quartered in the town and asked for help. But this officer refused because he understood full well the feelings which motivated Jean Joseph Pasteur and approved of them. As a result Pasteur was allowed to keep his sword.

Again he settled down to his tanner's trade and soon he came to be known to many of the neighbors as the "old soldier" even at only twenty-five. One person, however, did not call him the "old soldier" and her name was Jeanne Étienette Roqui. She lived just across the river Furieuse from Pasteur's tannery yard. Often, in the early morning especially, Jean Joseph would watch Jeanne Étienette work in her father's garden—secretly, he thought. His actions, however, were not unnoticed by the young lady across the river who soon thought that the "old soldier" was not so old after all. It was not long before Pasteur became acquainted with her family that was descended from one of the most ancient plebeian families in France. The acquaintanceship between the two young people soon ripened into love. Pasteur asked for her hand in marriage and was instantly accepted.

The household built from their marriage proved ideal for their children. Father and mother seemed to be made for each other. Jean Joseph's careful, reserved mode of living balanced perfectly with Jeanne Étienette's activity, her imagination and enthusiasm. Her love for her husband had much to do with his endless consideration for the children.

Soon after they were married, they moved to Dole and settled down in the Rue des Tanneurs. Here their first daughter was born and four years later, Friday, December 27, 1822, at two o'clock in the morning, Louis Pasteur was born into this world. It was from this humble Catholic household that our Knight of the Laboratory began his crusade for a better world for all children and grown-ups.

At Dole another daughter was born. Shortly afterwards the family packed up and left for Marnoz, where the Pasteur home is still known. On one of its inner doors is a painting by Jean Pasteur that tells the story of his own life, that shows his longing for the army had not disappeared, even though he was proud of his wife and small family. The painting depicts a soldier, clad in an old uniform, leaning on a spade. The ex-soldier, now a peasant farmer, looks up into a gray sky and as he gazes, he dreams of days of glory gone by. He sees the flash of the sun on the eagles of Napoleon, the glitter of cold steel and the tossing of plumes. It seems as if the ex-soldier were waiting for a call from the distant hills, beckoning him back to the former days of glory.

Marnoz, however, did not prove to be a good place for a tannery, so the Pasteur family did not live there long. Louis was not yet old enough to attend school at Marnoz and he remembered very little of his life there. His recollections were confined to his playing near a brook which ran alongside of the Aiglepierre road. His real life began at the house at Arbois, just below the bridge over the Cuisance River.

Fronting on the street, the little house to which the Pasteurs moved had in the rear a tanning yard, with the water close by. In the yard were pits, dug for the preparing of the skins, where Louis and his friends spent a great deal of their playtime.

Indoors, Louis passed many hours working with his crayons. He attracted the attention of educated people in the village with his pictures and was called the "artist." It was nice to have their praise, but he liked better the grudging compliments of his father, who always tried not to spoil him.

At the primary school and the school that resembles our grade school, Louis couldn't be any too proud of his lessons. He was not quick to learn;

everything had to be studied thoroughly before he could recite it. He never affirmed anything unless he was certain of it. But going over the pages so often made him interested in them, as well as able to keep up in his class.

The primary schools in those days differed from the grade schools as we know them today. The pupils were divided into groups and over each group there was what was called a "monitor." This monitor was one of the brightest and smartest pupils of the group. Louis, many times, longed to be a monitor but he was just an average student. When the schoolmaster, M. Renaud, would go from group to group selecting monitors, Louis would look up at him with his big eyes that showed clearly his earnest desire to be allowed to act as monitor, but the schoolmaster never gave Louis the chance he longed for. The monitor acted in this way. When the time came for the reading lesson he would read a sentence and then the entire class would spell aloud the words in the sentence in a sort of singsong manner.

Even though Louis' father was no student, he made it his business to know educated men and to have them at his house. He made a point of increasing his own knowledge so that he could help Louis with his school work. He wanted the boy to earn his living with his brain rather than with his hands.

To Louis it seemed the natural thing to study thoroughly and to take his lessons seriously. His father and mother gave up much, worked day and night to provide for his schooling. They were always interested in what he learned. All their visitors, including the village priest, a doctor, a philosopher and the headmaster of the school, M. Romanet, asked him about his lessons. How could he expect to answer their questions if he didn't study?

But outside of school hours, Louis did not spend all his time with his books. One of his greatest delights and joys was to go fishing. Many times he and his youthful comrades would go on fishing parties up the Cuisance River. Jules Vercel especially was a very good fisherman and Louis delighted to go on expeditions with him. They never came home empty-handed.

Again, Louis and his playmates enjoyed going on long hikes through the woods, especially through the wooded heights above the wide plain, toward the town of Dole, where they would explore the ruins of the Vadans Tower, an old fortress rich in historical interest and which reminded them of the glory of heroic days.

In fact, all the citizens of Arbois were very proud of their local history. They considered themselves intensely patriotic and were inclined to boast not a little of their importance. Louis, whose patriotism in later life was second only to his love for God and his suffering fellowman, must have absorbed some of his feeling of patriotism from the citizens of Arbois. Yet Louis and his playmates were more interested as boys in the past history of Arbois than in its present.

For instance, in April, 1834, the Republic was proclaimed at Lyons. The citizens of Arbois rose up in arms against this government as soon as the news was brought to them. Louis and his friends watched the arrival from Besançon of two hundred grenadiers, four squadrons of light cavalry and a small battery of artillery, sent to pacify the Arboisians. This did not affect Louis half so much as some of the old stories concerning the bravery of the citizens of Arbois, especially the story concerning the siege of the city under Henry IV when Arboisians held out for three whole days against the besieging army of twenty-five thousand men. Stories of this sort worked upon his lively imagination and when he and his playmates were wandering through the woods, they would act out again and again some of the stories they had heard concerning the bravery of the Arboisians. These stories inculcated that intense patriotism which ever marked the life of our Knight of the Laboratory.

As Louis grew older, M. Romanet, the headmaster of Arbois College, began taking him on walks. Louis liked the master. He treated you like an equal instead of like a child. For instance, there was that Sunday afternoon when they strolled down the road toward Besançon that led between the green, vine-planted hills. To the left, on a tree-clad hill, the relic of the Vadans Tower seemed to throw a thrilling serenity upon the Sabbath quiet. It was like a picture out of a book, except that M. Romanet's voice made it a reality.

"What are you going to do when you finish the middle school, Louis?" he was asking.

"I don't know," Louis replied. "Father wants me to go to the college at Besançon and come back to teach at Arbois when I'm through there."

"How old are you now, my boy?"

"Almost fifteen."

"Have you ever heard of the École Normale?"

"A little. Why?"

“Well, they have much more to offer you there than at Besançon. You have to be a Bachelor of Science or Letters to enter, but you’ll be better off in the end.”

“But Paris is two days’ journey away. And it would cost much to go there.”

“I know. But the École Normale is the place for you to go. Take my advice, Louis. You are a true scholar. You know how to study. And you’ll be a real man—not a drudge—besides. France and the world of knowledge need men like that.”

The more Louis thought about the École Normale, the more he wanted to go there. Yet his father regretfully vetoed the idea. The boy was too young to be so far from home. And the expense was too great.

M. Romanet kept the subject alive in the Pasteur household, but it was Captain Barbier, a soldier who spent his leave with the Pasteur family, who settled the issue.

“And how is the boy?” he asked of Louis before the Pasteurs at dinner.

“Very fine, sir,” Louis returned respectfully.

“I hear you do well in school?”

“Very well,” M. Pasteur put in. “M. Romanet, his headmaster, says Louis is a fine student. I am very proud of him. It was my ambition to give him a hunger for learning. He is to be a teacher.”

“Where will he get his degree?”

“M. Romanet wishes he could attend the École Normale in Paris. But the entrance requirements for the École, I understand, are quite severe and a special preparation is necessary. Few schools are equipped to give a boy this preliminary training. Unless one would send his son to a preparatory school in Paris, the chances of qualifying are extremely slim. I feel that I cannot afford to send him to Paris, nor feel safe in letting him go so far from home.”

“Too bad. I can understand your feelings.”

“Yes. But the boy can do very well with a degree from Besançon. That is much to be thankful—”

“But wait—” the captain broke in.

“Yes?” Louis’ hopes rose, his face lighted, as did his father’s.

“I am stationed at Paris. I seldom leave. I could keep an eye on the boy. He doesn’t look like a mischief-maker.”

“But the cost?” the two Pasteur faces fell again.

“Simple. In the Latin Quarter, in the Impasse des Feuillantines, is a preparatory school run by a M. Barbet. He often takes boys from the country at half tuition.”

Could this be true? Was he, Louis Pasteur, really going to Paris and later to the École Normale? Louis turned wishing eyes on his father.

“Can you make arrangements with M. Barbet to admit Louis?”

“Very likely. I will contact him as soon as I return.”

It seemed years before the letter from Captain Barbier arrived with the news that M. Barbet would accept Louis if he came to Paris. The boy looked from his mother to his father, trying to read their decision. No word was spoken for more than sixty seconds. Then Mme. Pasteur rose to her feet, crossed to Louis, laid a friendly arm around his neck.

“We will hate to see you go, Louis,” she said slowly. “But we want to give you everything you need to face the world. That is our duty to God and to you. I know your father wants you to go.”

“Yes,” Jean Pasteur finally nodded. “I do.”

The bustle of getting ready was twice as exciting when Louis learned that his friend, Jules Vercel, was also going to Paris and would travel with him. The boys’ families were in constant discussion as to what to pack for their sons, what stage should be taken, what everything would cost. Sometimes the excitement was interrupted by a moment of thinking how empty their homes would be without the two lads, but there was little time for regrets until the endless minutes before the stage left.

Then instead of a promising student worthy of traveling to Paris, Louis’ father and mother saw only a scared boy, wet and cold, wishing he could get off the stage and run back home—and staying on the seat because of the hidden spark, the unquestioning fate that was to carry him along.

Louis was thoroughly cold and miserable. But he wouldn’t quit.

“Wanta go home?” he mumbled under his breath to Jules.

“Do you?” Jules tried to taunt between chattering teeth.

“The Knights of Arbois never went home licked, did they?” Louis demanded. “Well, I’m going to ride into Paris with my banners flying.”

Chapter II Pass or Fail

Louis, though his face did not betray him, failed to live up to his resolve. He did not ride into Paris with banners flying. All the way to the city, even when they stopped in Dole, or Sens, or Fontainebleau to change horses, he couldn't tear his mind away from Arbois. When they rumbled onto the streets of Paris, when Louis got his first glimpse of this great city with its huge buildings of stone, its crowded streets, men hurrying on mysterious errands, actually dodging horses' hoofs in their mad haste and, in contrast, the lolling crowds contentedly sipping their coffee at the sidewalk cafés, he was not impressed. He wished, instead, he were plowing into the streets of Arbois.

Soon after their arrival at the hotel-station in Paris, where they were met by a representative of M. Barbet's school, the boys got their first look at their new home. It was not very impressive, situated in the crowded Latin Quarter among rundown tenement houses. They were assigned to a small cell-like room which already had another occupant. Three to a room was the rule at M. Barbet's.

Louis wondered where the classrooms were and was soon told that the students attended classes at the Lycée St. Louis or at the Sorbonne. M. Barbet's school was a place where students lived and studied only. There were no actual classes except for private tutoring.

Every night in the dormitory on the Impasse des Feuillantines was as bad as the first one. Louis could not sleep, could not forget his home, even tried reciting poetry to lull himself into rest.

Attending classes at the Lycée St. Louis was no better. In spite of his willingness, his intense interest in the studies, he couldn't concentrate. "If only I could get a whiff of the tannery yard," he told Jules Vercel, "I feel I should be cured."

Even the kindness of M. Barbet, who understood his plight, seemed to do no good. Louis knew he was not doing his lessons properly, and was ashamed of himself because of that fact. But M. Barbet would try to interest him, try to draw him out. Finally the master realized the matter had come to the point where Louis' health was showing the results of the sleepless nights.

Louis hated himself for being homesick when the rest of the boys seemed to get along after the first few days. He did not realize he had been blessed with parents who had shared his life far more than most parents. He took it for granted that all parents were chums of their children.

Louis could not sleep, could not forget his home.

One morning, after Louis had been at school for almost a month, a messenger called him from class. Listless with loss of sleep and skimped meals, he walked down the street to the café on the corner where the messenger had instructed him to present himself.

The room seemed deserted. He walked farther in toward the rear of the place, where some of the tables were in shadow. Suddenly a smile burst across his face as he ran to a corner table.

"Father! Father!" he cried again and again, as he threw his arms around the welcome figure.

M. Pasteur patted his son's shoulder shyly.

"You are glad to see me, Louis?" he asked softly.

"I wish I could tell you how glad!"

"I know, my son. I was almost as young as you when I went to Spain for the war," the father said quietly.

"But why are you here? Did you come to see me? How is everyone at home?"

"Everyone is all right at home. I came to take you back. Come, let us go and pack your things. M. Barbet wrote me about you."

Without another word M. Pasteur led his son out of the café and went with him to help gather up his things. The school was behind them before any of Louis' friends returned from class.

Shyness kept Louis from mentioning the matter, but he murmured a prayer of thanks for having so kind a father. He wished there were some way to tell him how grand he had been not to ask any questions, not to raise the issue of going back home or staying in Paris. His father had understood he couldn't stay and had told him to pack for the trip home without even trying to coax him to remain.

Louis hated having to admit defeat, but this one bad break wasn't going to ruin the rest of his life. He was determined to make up for lost time. Back to school in Arbois he went, to earn more prizes than he could carry home at the end of the term.

During that year, he did not show his disappointment at the failure of the Paris trip, but, like his father after the Spanish War, he turned more within himself, invented his own solitary amusements. He took to his crayons again and won praise for his drawings throughout Arbois. Gladly, he undertook

portraits of anybody who asked for one, finally climaxing his achievements with a picture of the mayor. The compliments of this official, coming at the end of the school year when Headmaster Romanet praised him for his success in graduating from the Arbois school, strengthened Louis' courage, his determination that he should make another try for the École Normale.

Rather than go to Paris for his preparation, Louis decided with M. Pasteur that the best way would be to attend the Royal College in near-by Besançon. Their plan proved to be thoroughly successful. Louis found himself under a philosophy master named M. Daunas who took the same friendly interest in his progress and his pleasures as had M. Romanet in Arbois and M. Barbet in Paris. M. Daunas was a graduate of the École Normale and told Louis of all he would find there, the learning and the living. Louis' desire to enter this great school, founded by Napoleon in 1808, grew stronger with each of those talks.

The science master, M. Darlay, however, did not share M. Daunas' interest in the young man's career. During a certain class, Pasteur became so interested in Darlay's explanations that he forgot his usual shyness and repeatedly interrupted the lecture with questions.

Becoming annoyed and embarrassed, M. Darlay exclaimed: "Who is teaching this class, M. Pasteur, you or I? It is my province to ask questions, not yours!"

"I'm sorry," said Louis.

Nevertheless, Louis' interest in science was born at the Royal College. He forgot outside amusements, even drawing, in his hungry desire for more knowledge of science. For the first time, Louis' thorough, searching habits of study were swept ahead by a burning enthusiasm. At the end of the term, his highest grade was in science.

In a letter home, he spoke of giving up drawing, though one of his pictures had been placed in an exhibit.

"All this does not lead to the École Normale," he wrote. "I prefer a first place at college to ten thousand praises in the course of conversation."

But Louis Pasteur was not sacrificing his hobby and his leisure-hour pleasures to become a dry professor, buried in a dusty library. He visualized himself as slowly buckling on his armor to fight for a better world of science. Just as the knights of old left King Arthur's Round Table, armed with Faith and Courage and Strength, to battle a dragon in a murky cave, or as the Knight Crusaders mounted their steeds with the cry "God Wills It" on

their lips and in their hearts, he was preparing himself to ride into the unknown darkness of science to battle for a healthier and better world.

It was in 1840, when he was eighteen years old, that Louis won his degree of Bachelor of Letters.

Toward the end of the summer holidays, from the headmaster of the Royal College at Besançon came an offer of work as preparation master for the younger students while he continued at the school his own work on higher mathematics, in preparation for the École Normale. He would be allowed a small salary and free room and board.

He accepted and went.

By this time, the boy had grown into a man. Living away from home, working on a subject that was too exciting to leave, he merely had to keep on with his consistent effort to succeed as a tutor. His students liked him and consequently did well in their studies. In a letter written about this time to his sisters, he stated in very serious words the way that he worked.

> To will is a great thing . . . for Action and Work usually follow Will, and almost always Work is followed by success. Will opens the door to success both brilliant and happy; Work passes these doors, and at the end of the journey Success comes to crown one's efforts.

These are profound words for a young student of eighteen, but Louis had faced much in his eighteen years. He had discovered that to earn what one wanted, to be successful in life, one had to work and work hard. Then having done one's best, to trust in God.

Louis passed on this advice to his sisters, for he thought a great deal of them. He truly loved them and was anxious to instill in them ambitions equal to his own. The strong tie of love that bound him to them was probably a family trait inherited from his mother. She was a Roqui, and that ancient plebeian family was noted for the ties of love that bound its members together. In fact "to love like a Roqui" was almost a proverb in France.

The Pasteur household was based on two loves—love for each other and love for God. Louis showed his love for his sisters in many ways. When he was at home he would help them prepare their lessons in the evening before the father gave the signal for night prayers. He would accompany them to church for Mass, as well as join them in picnics up the river.

One evening, Josephine, Louis' favorite sister, broke the silence with, "I simply cannot study any longer. This grammar lesson is so hard."

"Let me help you," said her brother, as he came to her side and placed an arm around her. "See, this is the way to parse that sentence.

"You know it is very difficult to be patient sometimes," he continued, "but obstacles can be overcome by work and when one becomes accustomed to work, one can no longer live without it. Someday, Josephine, you will find that out."

His letters to his sisters from the Royal College at Besançon contained many similar admonitions and as a rule he would end his letters to them with, "Love each other as I love you." His love for his sisters led him on one occasion to offer his salary from the Royal College to help toward their education.

At Besançon Louis Pasteur met a young man who became his lifelong friend. Charles Chappuis, the son of a notary of St. Vit, was also preparing for the École Normale but specialized in literature rather than in science. The two young men, both striving for the famous school, were soon constant companions. On their long walks together in their leisure hours, they would talk of both books and chemistry. Pasteur was as fond of books as the literary student. Chappuis felt almost as much interest in the laboratory.

Charles was the first real friend Louis had ever had in school. He was thoroughly happy when they were together, exchanging confidences, talking about things Louis had always been too shy to speak of to anyone outside of his family. They talked of Arbois and St. Vit, of their parents, their ambitions. Before the year was out, they were as close as brothers.

Pasteur also gained in Chappuis a leader whose good influence appeared throughout his life. He found a joy in literature that balanced his own passion for chemistry and physics. Through Chappuis, he avoided letting his mind slip into a narrow, intolerant rut by keeping it alive through the teachings of God and man.

At the end of the year, Charles went to Paris for his final preparation for the École Normale. Louis wanted desperately to go, but his father thought it better for him to stay. Probably he was afraid of a repetition of the painful failure of Louis' last trip to Paris.

A letter from Chappuis in Paris made Louis even more anxious to go. Charles missed him. What good times they could have! Perhaps they could study together!

But, "Next year," was M. Pasteur's brief answer to all his son's arguments.

So, back again at Besançon, Louis threw himself day and night into his studies, trying to forget the absence of his good friend. Still working as preparation master and student, he took extra lessons in mathematics. For a while he considered taking, along with the École Normale examination, the tests for another great school, the École Polytechnique. He even wrote Chappuis about his idea.

> I shall try this year for both schools [he said in a letter to his friend]. I do not know whether I am right or wrong in doing so. One thing tells me I am wrong; it is the idea that we might be parted; and when I think of that, I believe that I cannot possibly be admitted this year into the École Polytechnique.

Chappuis replied, like the unselfish friend that he was:

> You know your tastes. Think of the present and also of the future. You must think of yourself; it is your own fate you have to direct. There is more glitter on one side; on the other the gentle, quiet life of a professor, a trifle monotonous perhaps, but full of pleasure for him who knows how to enjoy it. You, too, appreciated it formerly, and I learned to do so when we thought we should both go the same way. At any rate, go where you think you will be happy and sometimes think of me.

Either Charles' letter or the study of mathematics cured the young Knight of the Laboratory of the Polytechnique. In fact, he said of mathematics after an exhausting day of study: "One ends by having nothing but figures, formulas and geometrical forms before one's eyes. . . . On Thursday I went out and I read a charming story, which, much to my astonishment, made me weep. I had not done such a thing in years. Such is life."

Also, Pasteur realized the Normale examinations would be plenty to manage without preparing for those of the other school. He had talked with a friend of Chappuis who had lately entered the Normale at the head of the class—but who still trembled when he mentioned the examinations he had taken.

"Were those examinations difficult!" exclaimed this friend to Pasteur in answer to a question the latter had asked. "You know you have to pass one

written and one oral examination in every subject."

"Were the written tests very hard?" questioned Louis further.

"Well, they were difficult enough, but at least you had time to think, but those orals! Just imagine walking into a room, standing in front of a table. Opposite you are the examiners, stern-faced and sour-looking. You almost think that you had committed a crime and that these men were the judges with the power to sentence you to life imprisonment. Then the questioning begins and with your knees knocking together you stammer out your first answer. Believe me, I don't care to go through that again."

And at Besançon Louis had ample proof that the going would be anything but easy when he faced the test on August 13, 1842.

> If I do not pass this year [he had written to his father] I think I should do well to go to Paris for a year. After talking to some who have taken the examinations, I can see now what advantage there is in giving two years to mathematics; everything becomes clearer and easier.

But he goes on:

> Of all our class students who tried this year for the École Polytechnique and the École Normale, not a single one has passed, not even the best of them, a student who had already done one year's mathematics at Lyons.

Louis once received a first in physics and was twice second in the class, but his average grades were no more brilliant than they had been. The fate of his classmates in the examinations for the Normale, classmates whom he considered better than himself, made the day of the examinations look as black as a thundercloud.

The examiners, the students, everything in the room on that fateful day seemed to upset him. This test meant so much. Whether he could enter the École this year or must spend another year in study. Whether he could live up to the hopes of his parents, who had sacrificed so much for his education. Whether he was really to be successful in life.

When he left the hall, after the final examination, he had no idea whether he had passed or failed. One minute he was convinced he would sweep through with flying colors. Another he feared dismal failure.

Thirteen endless days dragged by. Would those judges never tell him the results?

Then the long-awaited answer came. Louis Pasteur had passed his examinations. But unfortunately the young scientist's grades were not all that he had hoped. Out of a class of twenty-two, he stood fifteenth.

He was declared admissible to the École Normale. But even with this ambition finally gained, he was not satisfied. He had passed less brilliantly than he had for his Bachelor of Letters degree. His grade in chemistry was only *mediocre*. He decided to prepare for another year before entering the school.

So, the following October, five years after his first trip to Paris, Louis Pasteur boarded the stage with Chappuis for a year's study at the school of M. Barbet. But now he did not come to M. Barbet as a forlorn lad. He had grown up. He was more sure of himself. He came as a tall young man, full of energy, ambition and enthusiasm for his work. His school fees were reduced to one-third of the regular charges. In return he was to teach younger pupils mathematics from *six to seven each morning*.

Though he did not have the privacy of his own room as he had at Besançon, he did have Chappuis and the opportunity for far better instruction than at the old school.

> Do not be anxious about my health and work [he admonished in a letter to his parents]. I need hardly get up till 5:45, you see it is not so very early.
>
> My Thursdays I shall spend in a neighboring library with Chappuis, who has four free hours on that day. On Sundays, we

> shall take a stroll and work a little together. . . . I also shall read some literary works. Surely you now know that I am not homesick this time.

Though all his classes at the Lycée St. Louis were of great interest to him, Louis Pasteur was most impressed by the lectures at the Sorbonne by M. Dumas, and there again saw reason after reason why his own life should be devoted to science. In December Louis wrote:

> At the Sorbonne, I attend the lectures of M. Dumas, a celebrated chemist. You cannot imagine the crowds of people that come to these lectures. The room is immense, and always quite filled. We have to be there half an hour before the lecture is scheduled to begin to get a good place, just as if you were going to a theater; there is also a great deal of applause; there are always six or seven hundred people present.

At one of these lectures, Dumas conducted an experiment solidifying carbonic acid. For this he needed a handkerchief or a cloth to collect the snow resulting from the solidification, so he asked, "Has anyone here a handkerchief?"

In a moment Louis bounded onto the platform, offering his handkerchief for the experiment. Dumas instructed him to hold it in such a way as to collect the snow as the carbonic acid solidified. After the demonstration, Louis carefully folded the handkerchief and kept it for years as a precious relic.

It was not long before Louis had made himself so useful at M. Barbet's that he was excused from paying even his one-third tuition. But he kept a close record of all his expenses. His father insisted that he dine with Chappuis on Thursdays and Sundays, though Louis would have preferred not to spend the money. As it was, he always held these meals at the Palais Royal to less than fifty cents on every occasion.

The room Louis occupied at M. Barbet's Boarding School became quite chilly during the winter months, making it extremely difficult to study properly. One day he said to Chappuis, "Let's go out and look at some small stoves. I think I'll buy one for my room."

After pricing the stoves, Louis decided it would be cheaper to rent one for a few months. "After all," he said to his friend, "I only need it for a few

months." Continuing their shopping expedition, they next purchased some wood.

Then Louis thought of something else he needed. The study table in his room bore on its top surface the carved initials of many previous occupants, making it extremely difficult to write properly.

"I think I'll buy a cloth to cover my table," he said to Chappuis. But after pricing table cloths in various stores the two shoppers found them to be quite expensive.

"Let's try one more store," said Chappuis. "Perhaps this little place here has one on sale."

The two young men entered the store.

"Have you any cheap table cloths for sale?" asked Louis of the shopkeeper.

"Oh yes," he answered. "See this beautiful red one? It is only fifty cents."

The two shoppers thought it to be a bargain and purchased it. Arriving at the school, the stove was set up and soon a fire was kindled. Then Louis opened the package containing the table cloth. Carefully he prepared to spread it on the table top. Suddenly his face fell and a look of dismay swept over his features—the table cloth was full of holes. So much for his bargaining powers!

Most of Louis' time went into hard work. When he took his second examination for the École Normale, he stood fourth in his class. So, not long before his twenty-first birthday, Louis Pasteur was eligible to enter the École Normale. He had achieved the ambition for which he had struggled so long.

After a short time at Arbois, he reported to the École Normale before any other students arrived. Now he stood like a knight on the edge of the lists. To him the air of destitution of the place, the crumbling walls of this decrepit annex of the Louis Le Grand College represented all he could ask for in life. Here he could enter the contest of Science in earnest. He was no longer a schoolboy, he was a man being trained as a scientist and a teacher.

His forehead was already broad, his nose wide at the nostrils. His eyes showed no signs of wavering as he scanned the building. Every feature was a fighting feature, his face the face of a man increasingly sure of himself. He had come far. And that square chin showed he was going farther. There was

strength in his step, faith in himself shining from his whole being as he marched into the École Normale.

At this school, Louis had little free time, but the bulk of those few hours were spent in the library or in the Sorbonne laboratory. His father constantly wrote Chappuis, asking him not to let Louis work too much, and the good friend did his best to get young Pasteur to give up his studies at least occasionally. Louis' burning enthusiasm for science, for experiments and for studying the lives of great scientists made it impossible to tear him away for long from his test tubes or books.

Finally Chappuis took up a waiting game. He would sit on a stool in the laboratory and wait patiently while Louis worked, saying nothing. After half an hour of this, Pasteur would agree impatiently, "Well, let us go for a walk." But they would go right on into talk of philosophy and chemistry or of their classes and the laboratory, just as if they weren't on an outing.

One afternoon in the Luxembourg Gardens, Louis mentioned the subject that was to bring him his first prominence in the world of physics and chemistry.

"Charles," Louis was saying, "I have been doing a great deal of thinking about racemic—or some call it paratartaric—acid. One day, in the library, I came across an article on this subject and it has interested me ever since. A manufacturer in Alsace, M. Kestner, discovered some by chance when he was making tartaric acid. Now he cannot make it again, though he's tried often enough. I've been wondering if I could find out why."

"I don't know, Louis. Possibly," Chappuis replied, his mind on philosophy lectures.

"It would be hard. Mitscherlich, the German chemist, and Biot, the physicist, have both studied on it and can come to no conclusion."

"Perhaps not, then."

"You see, if you take polarized light, light going straight in one direction, and direct it into a solution of tartaric acid, the solution bends the direction of light, but, in paratartaric acid, the light goes through without bending."

"But what does it matter whether the light bends or not?"

"A great deal. Since all kinds of crystals, all kinds of chemicals, react differently to polarized light, you can often distinguish between them by these bending reactions. When you put solutions of sugar in a polariscope

under polarized light, they bend the light to the right, just as does tartaric acid. Essences of turpentine or quinine bend the plane of polarized light to the left."

"And what good does that do?"

"By making use of it, you can tell just what different elements are contained in certain materials. It would have a great business value and also be useful in a medical way."

Louis did not realize how accurately he had prophesied. Not many years later the saccharimeter, built on the principle of polarized light and crystals, was being used by manufacturers to discover the quantity of pure sugar contained in commercial brown sugar and by physiologists in following cases of diabetes.

Soon after Louis came to the École Normale, he was made an honorary member of the Arbois College faculty. His old master, M. Romanet, often read Louis' letters to the senior class. The following summer M. Romanet asked Louis to give a few talks to the students of Arbois College. These lectures, as M. Romanet requested, were summaries of some of the talks Louis had heard at the Sorbonne and at the École Normale. Truly Louis was already the pride of Arbois and especially of his old headmaster who had encouraged him in his early school days.

Louis' curiosity about changing matter from one form to another was a key to his endless interest in his work. In one of the lectures he attended, the method of obtaining phosphorus was described, but lack of time prevented a laboratory demonstration being made.

Louis satisfied his curiosity by going out, buying a handful of bones and burning them. Very carefully reducing them to a fine ash, he treated the ash with sulphuric acid and proudly extracted about sixty grams of phosphorus that he displayed on a shelf in his room.

His friends teased him about being a "laboratory pillar." Some did get ahead of him in class work while he spent his time on what they thought was his puttering. But out of the fourteen candidates in the final examination for a professorship in September, 1846, Louis was third of the four that passed. And his results in physics and chemistry brought the jury's recommendation, "He will make an excellent professor."

All students of the École Normale, after passing their examination for professorship, had to spend ten years in teaching. This was a government

rule. Louis was now eligible to be appointed a teacher whenever the Government wished to do so. And it was not long before the appointment came. It was for a small place, Ardeche. But Balard, Pasteur's chemistry master, took him into his own laboratory as an assistant and so managed to rescue him from being shipped away at once to the little town as a teacher. The master had every confidence in a brilliant future for Louis and refused to have him buried in a village just when instruction in Paris was most valuable.

Louis, in turn, was devoted to Balard. He was deeply grateful for Balard's good turn. He could ask for little more than to work under this chemist who had become famous at the age of twenty-four for his discovery of bromin.

A strange, poetic, yet erudite young man came into Balard's laboratory toward the end of that year. His name was Auguste Laurent, a former professor of the Bordeaux faculty who was both a poet and a scientist. He would not say definitely how he came to leave Bordeaux. Perhaps he did not get along with the heads of the college or, as he remarked, he simply wished to live in Paris. Nevertheless, he was well known in the scientific world and was a correspondent of the Academy of Scientists.

Laurent exerted a great influence on Louis' future. He was another in the chain of great men who were impressed by the young Knight of the Laboratory and shared their wide knowledge with him, instilled in him some of their own enthusiasm.

This romantic man of facts had made his name by proving the theory of molecular substitution, stated by Louis' chemistry master, Dumas, back in 1834, which announced that "chlorine possesses the singular power of seizing upon the hydrogen in certain substances, and of taking its place, atom by atom."

Talking to a friend, Louis had a much more simple explanation of the theory. The two were chatting of Laurent and Dumas.

"It's a real experience to study under Laurent," Louis said. "He's just asked me to help him in some of his experiments."

"How will that help your work?"

"Oh, the practical laboratory training will help a great deal, but his theory of molecular substitution might help me in my study of crystals."

"What's that theory all about? Sounds pretty complex to me. Molecular substitution is a big phrase."

“Oh, that’s very simple. Just imagine that a molecule, a globe of a compound, is a monument of stones, with each atom of an element as one stone. The theory of molecular substitution merely proves that you can take these stones of one element out of the monument one by one and replace them with stones or atoms of another element.”

“And these stones or atoms will fit in and make just as solid a monument as before?”

“That’s it.”

“You’re smarter than I thought.”

“No,” Louis returned, “I have more to learn than I can in a lifetime.”

But it was to Chappuis that he really expressed his delight at working with Laurent, finishing with his usual down-to-earth statements.

“Even if the work should lead to no results worth publishing,” he wrote to his friend, “it will be most useful to me to do practical work for several months with such an experienced chemist.”

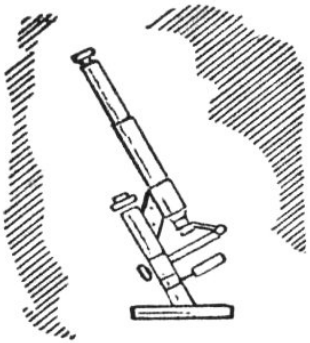
His work with Laurent did provide a chance for a closer study of his beloved crystals before their collaboration ended when the master was elevated to an assistantship to Dumas at the Sorbonne. Louis turned his greatest efforts then to his theses for his doctor’s degree.

These two papers, dedicated to his father and mother, bore frightening titles but really dealt with the physics and chemistry of the crystals he had studied ever since his talk with Chappuis about the effect of polarized light on racemic acid and the tartrates.

For physics, his essay was a *Study of Phenomena Relative to the Rotary Polarization of Liquids*; for chemistry, *Researches into the Saturation Capacity of Arsenious Acid. A Study of the Arsenites of Potash, Soda and Ammonia.* But, these big words were light labor for him. He wrote to Chappuis that he had only scratched the surface.

“In physics,” he wrote, “I shall only present a program of some researches that I mean to undertake next year, and that I merely indicate in my essay.”

Louis was not so interested in an actual diploma to be framed as he was in the actual work that was also his absorbing hobby. Nevertheless, he was not exactly calm when he presented the essays to the judges and returned home to await their decision.



Louis read and defended his essays on August 23, 1847, and although they were not enthusiastically received by the judges, yet he was successful in his presentation. But the doctor's degree was only a milepost at which Louis Pasteur did not pause. He had had a letter from his father saying: "We cannot judge of your essays, but our satisfaction is no less great. As to a doctor's degree, I was far from hoping as much; all *my* ambition was satisfied with the license to teach."

After receiving his degree, the newly made doctor visited his home for a short vacation. He was accorded a loving reception by his parents and sisters who were somewhat overawed by the academic distinctions heaped upon their son and brother. The same greeting was accorded him by his old schoolmaster, M. Romanet, and by his old chums of boyhood days, Vercel, Charrière and Conlon.

But it was impossible for Louis to keep away for long from his crucibles and retorts. So back again to Paris and the laboratory. On March 20, Louis read a portion of his paper, *Researches on Dimorphism*, a study of crystals, to the Academy of Sciences, and received their approbation, even though the study's big words had been too stiff for M. Romanet at Arbois.

During the early part of 1848 a revolution flamed up in Paris which caused the abdication of the French king, Louis Philippe. Paris was in an uproar and Pasteur, thrilled by the magic ideas of liberty, equality and fraternity, his mind and heart moved by the brilliant writings of Lamartine, the poet of the revolution, had visions of an ideal republic. He enlisted in the

National Guard, a city militia intended to guard municipal liberties, founded in 1789, and whose first colonel was General Lafayette of American Revolutionary fame.

Having enlisted with many of his fellow students, Louis wrote to his parents:

> I am writing from the Orleans Railway Station where, as a member of the National Guard, I am stationed. A great and ideal doctrine is now being unfolded before our eyes. If it were required I should courageously fight for the holy and sacred cause of the Republic.

One day, returning from his station, Louis saw a crowd gathered around a kind of altar which bore the inscription *Autel de la Patrie*. One of the bystanders informed him that the altar was erected so that citizens might place donations on it for the cause of the new republic. Pasteur hastened to the École Normale, gathered all his savings, amounting to one hundred and fifty francs, and donated them to the republic.

Telling his father about his action, he received hearty approval. His father advised him to publish his donation in the journal *La Nationale* as a gift to the republic "by the son of an old soldier of the Empire, Louis Pasteur of the École Normale."

Still, though patriotism was in the air, though Louis' mind was filled with his duty to France and her people, he had time to think of his crystals. Anybody might have laughed at him for wasting time on the shapes of tiny pieces of chemicals, but he felt he was on the trail of a discovery that would mean much to chemistry. In those days, he did not know these bits of matter would lay the foundation for discoveries that would improve the health and lengthen the lives of mankind. He did not realize at this time that he would be the first to apply crystallography, the study of the shapes of crystals, to medicine and surgery, as well as to give it a greater importance in the field of chemistry.

But he had reached one conclusion about the tartrate crystals, from which he was trying to find the source of racemic acid. It was common knowledge that the tartrates bent a beam of polarized light to the right, while the paratartaric or racemic acid did not disturb the beam. It was also common knowledge that crystals of the tartrates had many-sided shapes and were dissymmetrical—that is, they were similar in a mirror reflection. Their

faces, or facets, were reflected in a mirror just as a left-hand glove reflects as a right-hand one and vice versa.

Louis Pasteur had hoped to prove that the entire crystals of the paratartrate had a different shape from the tartaric crystals, since they did not bend polarized light, and that, for this reason, the outside shape of the crystal would tell how the crystal would react to polarized light.

Eagerly, he studied the crystals of the paratartrates on the bench before him. Would they be symmetrical instead of dissymmetrical? Would they be different in shape from the tartaric crystals?

Slowly he paced up and down before the bench, finally coming back to the microscope. “I should not give up this easily,” he muttered to himself, placing other crystals of paratartrate on the slide.

“Hmmm,” Pasteur peered tensely into the eyepiece. “Yes, it must be. Yes, those two there are left-hand crystals, their faces inclined to the left. And here are more right-hand ones, with faces inclining to the right. Yet a solution of these crystals does not bend light in the polariscope.”

Then the young scientist paused again. An idea, a brilliant light, was bursting through his mind. His heart beat wildly. His whole body trembled. Left-hand crystals bent light to the left in the polariscope. Right-hand crystals bent it to the right. Could it be possible—could this fact be the reason why polarized rays were not affected by this combination of left and right crystals?

Carefully he picked over the crystals again, sorting them. The only way to prove his idea was by experiment. Mitscherlich had not mentioned finding right and left faces in his paratartrates. Perhaps this was the key to the whole matter. But he must take his time, leave no chance for a mistake.

Pasteur inspected each of the paratartaric crystals thoroughly. Every one that turned to the left he placed in one pile. Every one that turned to the right, he placed in another pile.

With shaking fingers, he counted the little bits of paratartrate, made sure there was an equal number in each pile.

“Now the solution,” he spoke to himself, dissolving one of the sets of crystals in a certain quantity of water.

Now into the polariscope.

Louis’ confidence grew as he made the first test. Yes, the solution of right-hand crystals turned the beam to the right, and with the left-hand

crystals, the beam was diverted to the left.

Pasteur paused to take a deep breath. Here hung the success or failure of his experiment. This test could bring him fame or it might be just another failure. The scientist proceeded to mix the two solutions. In his heart was a faith that all would be for the best. One failure would be just another stepping stone to the success that must come sooner or later, if he kept working for it. He gave the two liquids ample time to combine thoroughly.

Then for the polariscope. Would the light turn to right or left? Or would the rays pierce through unaffected? Would he know that right and left crystal solutions combined to make a neutral solution? And that the chemical content of crystals could be discovered by their outer shape? Or would he be no closer to knowing the composition of paratartaric acid than before?

His heart thundering against his ribs, he applied the light.

The beam was not turned, shone through without deviation to left or right.

"I have it! I have it!" Louis shouted, rushing out of the laboratory, down the hall.

In the passage he met Bertrand, one of the curators. Wild with excitement, he embraced the official as he would have hugged Chappuis. Babbling, he half carried, half dragged the surprised man out into Luxembourg Gardens.

"Yes, Bertrand, believe me, I have it," he cheered. "I know the secret of racemic or paratartaric acid—"

"Come, come, the world is not going to explode. Tell me calmly," the curator laughed, but he was nearly as excited as Louis.

"Well, the acid is made up of right- and left-hand tartaric acids. The right-hand is similar in every way to the natural tartaric acid secured from grapes and combines of its own accord with equal quantities of the left-hand tartaric acid. Since the effect of the two acids on polarized light—the right-hand acid turning the beam to the right and the left-hand turning the beam to the left—is exactly opposite, the two acids balance each other when mixed and the mixture of paratartaric or racemic acid does not turn the light at all. Mitscherlich's *problem* is answered."

"Splendid, my friend."

Chappuis, unfortunately, was not at the school at the time, but Louis' exuberant letter gave him all the details.

> How often [he said, along with the details of the experiment], how often have I regretted that we both did not take up the same study, that of physical science. We did not understand, did we, we who so often talked of the future? What splendid work we could have done and would be doing now; and what could we not have accomplished united by the same ideas, the same love of science, the same ambition! I would we were twenty with the three years of the École before us!

But only a little more than three weeks later, he had a painful letter to write to his friend. The exuberance was gone, the excitement of his first major discovery. His mother had died within a short time after an attack of apoplexy—before Louis could reach home to see her.

"She passed away in a few hours," he explained to Charles, "and when I reached home she had already left us. I have asked for a holiday."

At that moment, Louis' work was completely suspended. Weeks passed before he again had any zest for life, before he could again take his mind from the tragedy and apply it to science. His parents had been so great a part in his life. He had felt such deep gratitude for the sacrifices they had made to allow him to become a student that the loss of his gay mother was nearly unbearable.

For weeks Louis remained steeped in sorrow. He remembered when he was a little boy, how his mother would pack the lunch baskets for the children to take to school and how she would put in his little basket an extra sweet of some kind. How surprised he would be when he opened his lunch and how he would rush home after school to thank her with a great big hug and kiss. This and many other home scenes Louis reviewed as he was buried in his grief. How he would miss her! It seemed incredible that he would not see her any more.

Years afterwards, when a memorial plate was being placed on the old home at Dole where he was born, Louis said of his mother: "Your enthusiasm, my dear mother, you passed on to me. If I have associated greatness of science with the greatness of country, it was because you instilled these sentiments in me, you inspired me."

While Louis was at home, Balard, proud of his pupil and assistant, had bragged of his discovery of the constitution of racemic acid in the library of the Institute, where old Academicians would meet to chat. Dumas, Louis' much-admired chemistry master, listened seriously without a word. Biot,

equally revered by Louis as a physicist, had his doubts. He was over seventy-four years old now and found it hard to believe a young man of Pasteur's age could get to the bottom of a problem that had been too much for an older, much more experienced scientist like Mitscherlich.

Biot did not stop to hear more of Balard's loud praises. Instead he announced briefly:

"I should like to investigate that young man's results."

When Louis returned to Paris, Balard told of Biot's remarks. Immediately anxious to convince the grand old man of physics, Louis wrote him, asking for an appointment to call.

> I shall be pleased to verify your results [Biot's reply read], if you will communicate them confidentially to me. Please believe in the feelings of interest inspired in me by all young men who work with accuracy and perseverance.

They met in the Collège de France, a school of high studies in Paris where Biot lived. Louis was filled with uncertainty. What if the experiment failed? What if he made some blunder that would spoil this great opportunity to impress one of the greatest scientists in France?

Biot started the proceedings by bringing some paratartaric acid and setting it before Louis. Pasteur could see the old man was putting him to the most rigid test, was not going to allow anything to go unexplained.

"I have most carefully studied it," the physicist pointed to the solution. "It is absolutely neutral (does not bend the rays) in the presence of polarized light.

"I shall bring you everything," he went on, as Louis stared at the liquid.

Biot produced doses of soda and ammonia with which to make the crystals from the liquid. He was going to have Louis make those crystals before his very eyes.

When the materials were added to the solution which would produce crystals and the whole was put into a crystallizer, Biot placed it in a far corner of the room where it would not be disturbed.

"I shall let you know when to come back," he explained to Pasteur, as the younger man passed through the door.

For forty-eight hours, Louis heard nothing from Biot. Certainly those crystals should have started to form by now. He spent those hours that followed in anxious waiting. What if Biot had become displeased with the experiment? Or decided Louis' experience in laboratory work was not sufficient to make his discovery of the constitution of racemic acid worth taking seriously?

At last the summons came. The eagle-eyed old man again stood over Pasteur's shoulder during the next step of the demonstration. With great delicacy, Louis drew the finest crystals from the liquid and wiped them absolutely dry.

Would they turn out to be right-hand and left-hand, as they had in his own tests? Fearfully, he looked at each one thoroughly as he dried it. Yes, here were some of the right-hand. And here some of the left-hand. He placed them all on a pile on the bench.

One by one, he drew them out, showed Biot how some of them had right-hand formations, others left-hand. In the process, he separated the two kinds into piles, just as he had in his own tests.

"So you affirm," said Biot, "that your right-hand crystals will deviate light to the right of the plane of polarization, and your left-hand ones will deviate to the left?"

Louis nodded in confirmation.

"Well, let me do the rest."

Pasteur left while Biot was to prepare the solutions. In that time, he suffered far more pangs of anxiety than he had on the previous days of waiting. This experiment meant so much. If he could earn the approval of Biot, his future would be well settled. He would be considered seriously by the great men of science throughout France.

If Biot disproved his theory, he would lose ground that would be hard to regain. It would be twice as difficult to get back into this charmed circle of great men after a failure than it had been to climb this far in the first place.

And Biot was hard to please. Like any older man, he was none too willing to have a young doctor barely out of the École teaching him new things about science.

This waiting was agonizing. Why didn't Biot send for him? Why didn't he tell him the experiment was a success, instead of keeping him in this awful suspense?

Or had it been a failure?

Almost before the great scientist's messenger could return, Louis rushed to Biot's home. His eyes afire with excitement as the scientist first placed in the polarizing apparatus the solution that should bend the beam of light to the left.

Yes! Yes! The light was properly deviated! The experiment was a success!

"My dear boy," Biot said, taking Louis by the arm, "I have loved Science so much during my life that this touches my very heart."

Louis was exultant over the success of his discovery. Biot at once suggested they work together, so, with Biot's help, Louis soon published a paper covering his discovery of the make-up of racemic acid and the effect of polarized light. The title of the study was "*Researches on the Relations Which May Exist between Crystalline Form, Chemical Composition, and the Direction of Rotary Power.*" Biot gave complete credit to the young man, voicing also the approbation of Dumas, Balard and Regnault.

Biot and Pasteur turned their combined attention to the subject of polarization and began thorough research into its many sides. Here Louis was very happy. He had the chance to eat, sleep and think nothing but Science, day and night. He had the advice and assistance of a skilled and wise man, whose decades of experience were at Louis' disposal. What more could a young doctor ask?

The shadow of a Government appointment for teaching hung over those happy days, but Louis managed to avoid giving the matter too much thought. After all, the question was out of his hands. When the time came,

he would simply have to obey the call. Balard had managed to get him out of one appointment, but, since the Government had trained him at the École Normale for teaching, he must eventually accept a teaching post.

Before a great length of time, he was named to fill a vacancy at the Dijon Lycée. Biot complained that they were in the midst of great work and tried to have the nomination set aside. After much discussion, he succeeded only in having the time set ahead to the fall of the year.

Louis hated the thought of leaving the Paris laboratory for the town of Dijon, though he reported there properly in the fall. It was tough going, and preparing lessons for his class took almost all his time. His conscientious nature forced him to do the job thoroughly, even though Paris and her laboratories, rather than the classroom, was his native ground. He felt a great responsibility in seeing that his students gained something from their studies and worked endlessly to keep them interested all during the lecture hour. He found performing more experiments kept their attention and made them enjoy his classes, so he turned to this way of teaching.

He taught chemistry to both first- and second-year pupils. The first-year class contained some eighty boys and Pasteur often exclaimed that "it was a mistake not to limit classes to fifty boys at the most. For it is only with great difficulty that I am able to keep their whole-hearted attention toward the end of the lesson." However, he did solve the problem by multiplying experiments during the last few moments. His second-year class was delightful. It was not large and Pasteur said about them: "They all work and some very intelligently."

Meanwhile, in Paris, all his friends attempted to arrange some way for him to return, but their efforts did not budge the rules of the Government. Eventually, however, they succeeded in having Louis moved to a somewhat better post at Strassburg, as deputy Professor of Chemistry, where an old school friend, Bertin, was Professor of Physics.

Bertin was glad to welcome Pasteur to the University of Strassburg. "You must live with me," Bertin said to Pasteur when he arrived on January 15. "I have a house only a short distance from the faculty."

The Professor of Physics proved to be a fine companion for Pasteur. He had a quick wit and an affectionate heart. His philosophy of life was to accept things as they came and contrasted strongly with Louis' dynamic energy and ardent ambitions. Bertin often maintained to Pasteur that disappointments were often blessings in disguise. Louis, however, would not agree with him.

"All right," said Bertin one evening in their home, "I'll prove it to you."

"Remember back in 1839 when I was mathematical preparation master at the College of Luxeuil?"

"Yes, I do," answered Louis.

"Well, I was entitled to two hundred francs a month but I was refused payment. What did I do? Did I kick up a fuss? Oh, no, I quietly resigned. Then I went in for the École Normale examination, entered the school at the head of the list and here I am, Professor of Physics in the Strassburg faculty. If it had not been for that disappointment, I might still be at Luxeuil."

As Bertin concluded, Pasteur laughed heartily and said, "My friend, you should have been a debater."

As comfortable as it was at Strassburg, there was one drawback, it was such a long distance from Arbois. Pasteur longed for family life. His suite of rooms at Bertin's would be large enough to accommodate one of his sisters. He expressed this idea in a letter to his father, who immediately answered, stating: "You say that you will not marry for a long time, that you will request one of your sisters to live with you. I wish this for you and for them. In fact neither of them wishes for a greater happiness than to look after your comfort."

Louis had no more than received this letter when he was introduced to the new Rector of the Strassburg Academy, M. Laurent, no relative to the scientist of the name. The rector's home was a meeting place for the members of the faculty, who always found a hearty welcome awaiting them. Bertin accompanied Pasteur on his first visit to Laurent's home. Duly introduced to Mme. Laurent, he next met the two younger daughters. Then it was that Louis encountered his first distraction from the laboratory. He foresook the brilliant light of his crystals for the brilliant light shining from the dancing eyes of Mlle. Marie Laurent. It was a case of love at first sight for both Louis and Marie. This certainly was odd on Pasteur's part. Always slow to come to a decision in the world of science, he judged quickly in the world of love. The only explanation for this is that Marie possessed those qualities Louis had always admired. She was pretty, vivacious and gay, yet subdued; modest and yet capable of arousing no ordinary admiration. Pasteur had known her only about two weeks when he sent the following letter to her father:

MONSIEUR:

A request of the greatest importance to me and to your family is about to be tendered you on my behalf; and I feel it my duty to present to you the following facts, which may aid you in determining your acceptance or refusal.

My father is a tanner in the village of Arbois in Jura, my sisters keep house for him, and help him with his books, taking the place of my mother whom we had the misfortune to lose last May.

My family is in easy circumstances, but without fortune; I value what we possess at about 50,000 francs. As for me, I have long ago decided to give to my sisters the whole of what would be my share. Therefore, I have absolutely no fortune. My only means are good health, ambition and my position at the University.

I left the École Normale two years ago, an *agrégé* in physical science. I received a Doctor's degree eighteen months ago, and I have presented to the Academy a few works which have been very well received, especially the last one, a report on which I have the honor to inclose.

This, Monsieur, is my present position. As to the future, unless my tastes should completely change, I shall devote myself entirely to chemical research. I hope to return to Paris when I have acquired some reputation in my scientific works. M. Biot has often advised me to think seriously about the Institute; perhaps I may do so in ten or fifteen years; and after diligent research; but so far this is but a dream, and not the motive which makes me love Science for Science's sake.

My father himself will come to Strassburg to make this proposal of marriage.

Accept, Monsieur, the assurance of my profound respect and devotion.

P.S.—I was twenty-six on December 27.

This may seem to be a strange letter for a man in love to write to his prospective father-in-law. Never once did Louis mention that he loved Marie. He simply stated his qualifications as a chemist and the fact that he would be a good provider for his future wife. But such was the custom in those days. The fathers of the families decided as to the fitness of the young people to marry.

Louis was in an agony of suspense for weeks, for Marie's family was on a higher social plane than his own, but M. Laurent finally came to a decision, and Louis' father and sister, Josephine, traveled to Strassburg. During the period of uncertainty, Louis wrote to Marie's mother:

"I am afraid that Mlle. Marie may be influenced by early impressions, not favorable to me. I know there is nothing in me to attract a young girl's fancy. But I do know that those who have known me very well have loved me very much."

Louis was a little ashamed, too, that his mind and interest was divided between his Marie and his work. "I, who did so love my crystals," he once remarked in a letter.

But still, on May 29, 1849, when the wedding was about to take place, Louis was missing. Finally he was discovered in his laboratory, deep in an experiment, and brought to the church.

Writing to Chappuis about the wedding, he admitted this was a thoroughly important event in his life. "I believe," he wrote, "that I shall be very happy. Every quality I could wish for in a wife I find in her. You will say 'He is in love!' Yes, but I do not think I exaggerate at all, and my sister Josephine certainly agrees with me."

After his marriage, Louis' experiments continued with as much vigor as before—perhaps with greater energy. Mme. Pasteur, graceful and dignified, entered into his researches with great enthusiasm and was often in the laboratory assisting him or at her desk acting as his secretary in preparing the long and detailed notes that he made of each experiment of importance that he wished to report to Biot.

The five years immediately after his marriage were among the happiest of Louis' entire life. He spent his vacation time in Paris and his teaching time in Strassburg, where he would have worked in the laboratory every minute he was not in the lecture room had not his wife carefully watched his health and insisted that he take at least a reasonable amount of sleep.

Three children, two daughters and a son, were born to the Pasteurs during their stay at Strassburg. Louis Pasteur's domestic life was truly one of harmony and as yet he had not become famous enough to have his scientific life darkened by bitter controversies. A continual correspondence passed between him and Biot as step by step our knight climbed the ladder of success. Great scientists, like De Senarmont and Regnault began to notice

the growing importance of Pasteur's work, began to perceive in the results of his labors a spark of genius.

When Louis came to Paris in August of 1852 to see Biot, who had become almost a second father to him, the old scientist had prepared a great surprise for him. Biot loved Louis as a son and was ever thinking of the wisest course for him to follow in guiding his future, saving him from more than a few ill-advised steps suggested by more enthusiastic but less sensible admirers.

When Biot knew Louis had arrived in his hotel in the Rue de Tournon, he started on his morning walk around the Luxembourg Gardens and left this note at the hotel:

"Please come to my house tomorrow at 8 A.M., if possible with your products. M. Mitscherlich and M. Rose are coming at 9 to see them."

Mitscherlich! And Rose, his assistant! Louis was overjoyed. The interview turned out very pleasantly and eventually led to a long crusade for this Knight of the Laboratory.

> I spent two and a half hours with them on Sunday at the Collège de France, showing them my crystals [Louis wrote to his father]. They were very pleased, and praised my work very highly. On Tuesday I dined with them at M. Thenard's; perhaps you would like to see the names of the guests: Messrs. Mitscherlich, Rose, Dumas, Chevreul, Regnault, Pelouze, Peligot, C. Prevost and Bussy. You can see from this that I was the only outsider. They are all members of the ACADEMY. The chief advantage, however, of my meeting these gentlemen is that I have heard from them an important fact, namely, that there is a manufacturer in Germany who again produces racemic acid. I intend to go and see him and his products, so as to study thoroughly that elusive substance.

At this time it must be explained that racemic acid was a peculiarity of chemical research. It had been discovered in 1820 through an accident in manufacturing tartaric acid. All of a sudden it had ceased to appear and chemists the world over failed to obtain it again. Its elusiveness awakened in Louis his spirit of research. Like a true knight he determined to go in search of this semimythical substance, much as the knights of old went in search of the Holy Grail.

Mitscherlich believed that his manufacturer received his tartars, a substance from which tartaric acid was manufactured, from Trieste, so Louis immediately decided to go there.

"I shall go to Trieste," he insisted; "I shall go to the end of the world, I *must* discover the source of racemic acid, I must follow the tartars to their origin."

Biot and Dumas tried to restrain him until they could secure support of an official mission from the Academy or the Ministry for the trip. Failing that, they begged him to wait until they could subscribe a fund for him. Louis was even on the point of writing to the President of France for support of the crusade but, exasperated by red tape, he refused to stay until some money could be raised, finally rushed off on his own meager income.

In the meantime Mitscherlich gave him a letter of introduction to a manufacturer at Awischau near Leipzig, and Louis made this the first stop in his search. There he experimented with Austrian and Italian tartars, only to become more convinced that Trieste was the goal he sought. He left Leipzig, intending to go to Trieste and Venice.

Along the way he stopped at Vienna and met with another disappointment, but, to be thorough, he visited a second tartaric factory.

To his astonishment, he found work at the factory had been held up because of the presence of a substance they thought was sulphate of potash, which Louis immediately proved was racemic acid. In reporting the trip to his wife, he stated that racemic acid was to be found in the tartars of Austria, Hungary, Naples, Croatia and Carniola, while French tartars probably showed a much smaller racemic acid content.

Giving up the idea of going to Trieste, he stopped at Prague, where a chemist named Rassman stated he had found a way to produce racemic acid from tartaric acid. Louis was immediately congratulating the man, since producing the acid artificially was the last step in the chain of Pasteur's study of the subject and because the Paris Pharmaceutical Society was offering a prize to anyone who could manufacture the substance.

Rassman, however, had not produced the acid after all, so Louis turned his attention to the problem of obtaining racemic acid from tartaric acid on his return to Strassburg. Although he had little prospect of success, Pasteur kept at the job, in spite of one failure after another. At last there was a ray of hope. Then a telegram to Biot:

"I transform tartaric acid into racemic acid," it read, "please inform MM. Dumas and Senarmont."

> Here it is at last [he went on in a letter to his father], that racemic acid (which I went to seek at Vienna), artificially obtained through tartaric acid. For a long while I believed that that transformation was impossible. This discovery will have incalculable consequences.

And it brought great honor to Louis Pasteur. An entire sitting of the Academy of Sciences was devoted to his work and how he had produced racemic acid by keeping cinchonine tartrate at a high temperature for some hours.

There was the red ribbon signifying his election to the Legion of Honor, which he proudly displayed to his father—who had won his award in the Spanish Wars—on returning to Arbois. Also there was a prize of fifteen hundred francs, half of which he spent for laboratories for the students at Strassburg and half for his own work, and that of his assistant.

Louis' father was nearly beside himself with joy at the Legion of Honor award and wrote of it to Biot. The old scientist replied in a letter that describes his high opinion of Louis:

> The splendid discoveries made by your worthy and brilliant son, his devotion to science, his unceasing perseverance, the conscientious care with which he fulfills the duties of his position, all this had made his situation such that there was no need to solicit for him what he had so long deserved. But one might boldly point out that it would be a real loss to the Order if he were not immediately included in its ranks. This is what I did, and I am very glad to see that the too long delay is now at an end. I wished for all this the more as I knew of your affectionate desire that this act of justice should be done.

Back at Strassburg, Louis made two experiments that led him toward his next great discovery and strangely fitted into the work he was to do at his next school.

Working with a crystal, he broke a piece off one side, then dropped it into the liquid from which it had originally been made—the "mother-liquor" of the crystal. He was surprised to find, in a few hours, that the crystal had

resumed its original shape, that the mutilated part had been built back to the same shape as before.

He realized that this crystal replaced itself, just as human or animal wounds healed.

In the second experiment he discovered that, when fermentation took place in racemic acid, the living organisms fed only on the right-handed molecules of the acid and the left-handed remained unchanged. He had discovered that his studies of racemic acid could be applied to the subject of fermentation—to living organisms, to biology as well as to the field he had already studied! He had opened a new trail for his laboratory crusades! For his service to the world! At last his crystals were reaching the stage where they would affect the life and health of all men and animals!

The two discoveries Louis Pasteur made at Strassburg were strangely useful to him in a very short time, useful because of a new post in teaching.

A new Faculty, or school, of Sciences had been recently opened at Lille, in the north of France, in the heart of the industrial section. The institution was built at the expense of the town, and a department was put in to aid the factories in their problems in science, as well as to train young men for industrial and scientific work.

Pasteur was selected as a professor and dean of the school, probably because of his success as a practical research chemist, as well as for his success at Strassburg as a teacher.

His work at Lille as a teacher, just as at Strassburg, was never shirked and shows the character of Pasteur as much as his discoveries do.

When he made his opening speech on December 7, 1854, to which the public was invited, Louis Pasteur was only thirty-two years old but he made some remarks so thoughtful and keen that they were worthy of a gray-bearded philosopher.

He told his audience that his literary interests were just as important in his own life as his laboratory work, that they balanced his exacting task of figures and instruments. He could have gone on to say that his life continued to be successful because he saw the world outside of his work. He did not become lopsided. He relaxed with his family and his books, so that his mind was fresh when it returned to chemical studies. Knowing how to work and relax, he could work better.

Louis was particularly interested in his work at Lille because it gave the students practical experience. One feature was a diploma awarded after two years' successful work that qualified its holder to take over a position as foreman in a factory. In this way, modern scientific training was intended to improve the actual business success of the district. The school was not teaching dry theory but training its students for actual work.

Another feature of the institution allowed the students to run experiments themselves in the laboratory under the Dean's supervision. Present-day schools, of course, all have laboratories, but in 1854, only two or three schools in France were so equipped. Pasteur mentioned the great advantage of this laboratory in his opening speech:

> Where in your families will you find [he asked], where will you find a young man whose curiosity and interest will not be aroused when you put into his hands a potato, when from that potato he may produce sugar, from that sugar alcohol, from that alcohol, ether and vinegar? Where is he that will not be pleased to tell his family in the evening that he has just been designing an electric telegraph? And, gentlemen, remember this, such studies are rarely forgotten. It is somewhat as if geography were taught by traveling; such geography is remembered because one has seen the places. In the same way, your sons will not forget what the air we breathe contains when they have once analyzed it, when in their hands and under their eyes the different qualities of its elements have been resolved.

Then, as if he wished to balance the practical with the theoretical, Louis Pasteur gave us his first glimpse of his powers of oratory.

> Without theory [he continued] practice is but routine, born of habit. Theory only is able to bring out and develop the spirit of invention. It is important that you people of Lille, above all, should not entertain the opinion of those narrow minds who disdain everything in science which is not for immediate application. You remember Franklin's charming response when, present at the first demonstration of a purely scientific discovery, he was asked, "But what is the use of it?" He replied, "Yes, gentlemen, what is the use of a new-born babe?" And yet at this tender age there are already present germs of great talents that will bring future distinctions. In your baby boys, helpless beings as

> they are, there are magistrates of the future, scientists, heroes as brave as those who are now covering themselves with glory under the walls of Sebastopol. Similarly, gentlemen, a theoretical discovery has only the merit of existence, no more; it arouses hope, and that is all. But let it be developed, let it grow, and you will see what it will become.

Chemistry students in the schools today who enjoy the laboratory, working with test tubes and with textbooks, can realize that Louis Pasteur spoke the truth in that speech.

The rector of the school was well pleased with Louis' successes with the classes.

Within a few months the Minister of Public Instruction officially commended the rector, declaring that the success of the faculty was due to "that clever professor," M. Pasteur. In fact, the small theater in which Pasteur delivered his chemistry lectures became famous in the student world.

At the end of the year our young scientist wrote to Chappuis and revealed many reasons for his popularity and success.

> Our classes are very well attended; I have two hundred and fifty to three hundred people at my most popular lectures, and we have twenty-one pupils entered for laboratory experiments. I think that this year, like last year, Lille holds the first rank for that innovation, for I am informed that at Lyons there were but eight entries.
>
> Our building is fortunately completed; it is large and handsome, but will soon become too small, because of the progress of practical teaching.
>
> We are very comfortably settled on the first floor, and I have (on the ground floor immediately below) what I have always desired, a laboratory where I work at any time. This week, for example, the gas remains on, and experiments follow their course while I am in bed. In this way I can make up a little of the time which I have to give to the direction of all the many departments in our faculties. And then, besides, I am a member of two very active societies, and I have been intrusted, at the suggestion of the Counseil-General, with the testing of manures for the department

of the Nord, an important task in this rich agricultural land, but one which I have eagerly accepted, so as to popularize and enlarge the influence of our young faculty.

Do not fear that all these activities should keep me from the studies I love. I shall not give them up, and I trust that what is already accomplished will grow without my help, will grow with the help that time gives to everything that has in it the germ of life. Let us all work; that only is enjoyable, to quote M. Biot, who is certainly an authority on that subject. You saw the part he took the other day in a great discussion at the Academy of Sciences; his presence of mind, high reasoning powers, and youthfulness were magnificent, and he is eighty-four.

This unselfishness in devoting so much time to the school work, which is shown in Pasteur's letter to Chappuis, grew to even greater proportions. He took his pupils on tours of factories at near-by towns. In July, 1856, he escorted the same pupils on a visit to the factories in Belgium.

And through this work with the factories and the connection of the Lille plants with the school, came an inquiry that set Pasteur on his next step to scientific progress. Here is where the two discoveries he made in Strassburg proved to be useful.

In the summer of 1856, M. Bigo, who had a son in Pasteur's classes, met with difficulty in making beetroot alcohol in his factory. This same difficulty arose in other Lille factories. M. Bigo finally came to Louis for advice.

The idea of doing a local manufacturer a service and having experience in a local plant as a basis of some of his lectures appealed to the young scientist, especially because the problem was along the line of fermentation, which he was studying with great interest just then.

Fermentation had been the subject of a great deal of argument among scientists up to this time. No one could agree on the matter, and some of the theories would amuse many of our present-day students of science.

One of the most popular theories of the day was that fermentation took place when certain organic substances, dying, caused a disturbance which set in motion the molecules of the fermentative matter. Or, as the illustrious scientist Liebig held, certain albuminous substances in decomposing imparted a sort of "molecular movement" which, for example, broke up sugar into alcohol and carbon dioxide. This was the theory of fermentation most popularly held among scientists when Louis Pasteur began his

experiments to pierce the darkness which enshrouded the causes of fermentation.

Most scientists knew that fermentation took place in the making of bread, wine and beer. They knew it was the change that took place when yeast was added to a compound that contained sugar or starch. The compound split apart and gave carbon dioxide gas and a new compound.

Today when we bake bread, the carbon dioxide in the yeast raises the bread, while some of it goes into the air. When a man makes wine or beer, some of the gas passes off and the balance stays in to make the beer or wine bubble.

But what caused yeast to have this effect could not be explained in any way that would be accepted generally. Here was where the wild theories came in. And here was where Louis Pasteur was to open another field in chemistry, where he was going to make his first discovery that directly affected industry, the discovery that would eventually affect all disease.

Louis began this study of Bigo's difficulties by going to the factory almost every day. He took samples of the beetroot juice that had fermented and compared some of this beetroot juice that had passed through a filter with some that had not. For this purpose, he had only a student's microscope and a rough stove that burned coke.

He studied these various liquids thoroughly, now reaching one conclusion, then having it disproved by discoveries he made a few days later.

In a letter, Bigo's son tells of how these studies, which he watched Pasteur perform, eventually led to Louis' great discoveries in the field of fermentation.

> Pasteur had noticed through the microscope [young Bigo wrote] that the globules were round when fermentation was healthy, that they lengthened when alteration took place, and were quite long when fermentation became lactic. This very simple method allowed us to watch the process and to avoid the failures in fermentation which we often used to meet with. . . . I had the good fortune to be many times the confidant of the enthusiasms and disappointments of a great man of science.

This letter explains how Pasteur found the cause of the trouble at M. Bigo's distillery. He discovered that when the proper fermentation took

place the globules were round when seen through the microscope and that when the juice turned sour or lactic, the globules became long.

Studying these liquids, Pasteur spent a great deal of time outside his laboratory thinking about these tests on fermentation. It occurred to him that the cause of the trouble at the distillery might be the key to a fact governing all fermentations and their causes. He made this question the subject of his private researches. He published no papers on the subject because he wanted to be absolutely positive that his findings were correct, since they were far different from the facts accepted by most scientists.

During these studies, Pasteur was called to Paris where there was a vacancy in the Academy of Sciences in the section of mineralogy, the field that included his study of crystals. He did not want to go because he knew he would not make a success of campaigning for the office and because chemistry was now really his field instead of mineralogy. Biot, Dumas, Balard and Senarmont, his friends, all insisted on his working for the vacancy, and he came to Paris more to please them than to please himself.

It was at about this time that his work on crystals brought him the great Rumford medal, presented by the London Royal Society. Perhaps his friends believed this would help him in his campaign.

As Louis expected, the campaign was a failure, but he did have the pleasure of witnessing the reception of Biot at the Académie Française in February, 1857. In welcoming Biot to the Academy, Guizot paid Louis' teacher great honor.

"The events which have changed everything around you," Guizot said, "have never turned the course of your free and steady judgment, or of your peaceful labors."

The greatest pleasure in the whole event for Louis was when Biot presented him with his own photograph, taken in Regnault's laboratory. It showed Biot weary with age but with eyes still sparkling. When the old master gave it to Louis, he said:

"If you place this photograph near a portrait of your father, you will unite the pictures of two men who have loved you very much in the same way."

And Louis realized fully that these words were the truth, he knew that few young scientists have the advantage of the advice and love of a professor as great and as kind as M. Biot.

Returning to Lille, Pasteur was glad to get away from the red tape and politics of Paris but especially glad to get back into his laboratory and to resume his exciting study of fermentations.

Now he began his work on sour milk or lactic fermentation that was eventually to result in the pasteurization demanded by law in many American cities and towns.

In his notebook he drew the tiny globules which he saw through the microscope, globules similar to those he had seen in the fermentation of wine from Bigo's distillery that came from yeast.

These little globules he found in a gray substance sometimes arranged within a definite area. Other scientists studying sour milk had overlooked these globules entirely, but the tireless, thorough Louis realized they were a separate compound, rather than a product of the fermentation. After coming to this conclusion, he isolated the gray substance and decided to study it further. Perhaps here lay the right solution to the cause of fermentation.

He scattered a small portion of the gray matter into some milk. Immediately the lactic or sour-milk fermentation appeared. It was then that he knew that the gray substance was the ferment, the chemical that caused the fermentation or souring.

The other scientists of Pasteur's time had various theories about the cause of fermentation, but all of them agreed that life of some kind, animal life or some living organism could not be the cause. Louis, however, was convinced that fermentation was an occurrence similar to life. He could see this lactic or sour-milk yeast budding and multiplying under the microscope, just as the beer yeast did or as all life does.

When he had written up the results of this strange and exciting experiment, he showed his loyalty to his school by presenting the paper to the Lille Scientific Society, thereby giving them the honor of presenting the work to the Academy of Sciences as work done by their school, through its dean of sciences, M. Louis Pasteur.

About the time this paper was read to the Academy of Sciences, Pasteur was assigned to the post of Director of Scientific Studies at the École Normale, by the Minister of Public Instruction. In a way he hated to leave Lille but he felt that his work there was well done. He had set a standard that augured well for the future of the Lille faculty. On the other hand, the École Normale was now but a shadow of its former self and Pasteur felt that it needed his help. And so the homesick boy who had sat on the stagecoach at

Arbois, who was now a brave knight in the crusade of science, was called back to the school he loved so well, the school he formerly gazed on with awe, to help it regain its former standing.

Going back to the École meant many sacrifices, especially giving up his laboratory at Lille for a tiny garret workroom where he was not even allowed an assistant. It meant taking care of endless details that cut into his time for private researches even more than had his class work at Lille. For Louis was not only Director of Scientific Studies, he was also in charge of the actual administration of the school; he was disciplinarian; he had charge of the economic and hygienic management, as well as the task of becoming acquainted with the families of the students and knowing the literary and scientific establishments frequented by those enrolled in the École Normale.

Biot was thoroughly angry that Louis should bear such a heavy burden, but young Pasteur took on the job with his usual energy and enthusiasm, the enthusiasm that the rector of the Lille faculty spoke of when he said:

"Our faculty loses a professor and a scientist of the very first rank. You yourselves have been able to appreciate more than once all the vigor and clearness of that mind, at once so powerful and so capable."

But Pasteur's garret laboratory, cramped under the roof of the École Normale, was the scene of more discoveries, in spite of his problems about catering, ventilation and upkeep of the buildings. In December, 1857, he had completed a study of alcoholic fermentation. Here, just as in the fermentation of milk, he found that the process was "correlative to a phenomenon of life, an organization of globules." . . .

Writing to Chappuis he spoke of this work.

> I find [he said] that alcoholic fermentation is always accompanied by the production of glycerine; it is an extremely curious fact. For example, in one liter of wine there are several grams of this product which never have been suspected.
>
> I should be following up the consequence of these discoveries if a temperature of thirty-six degrees centigrade [very hot] did not keep me from my laboratory. I am sorry to see the longest days in the year lost to me. But I have become accustomed to my attic, and I should regret to leave it. Next holidays I hope they enlarge it. You, too, are struggling against material hindrances in your work; let it encourage us, my dear fellow, rather than discourage us. Our discoveries will have the greater merit.

The following September brought a cruel blow to Louis in the death of his eldest daughter, Jeanne, from typhoid fever while she was staying with her grandfather in Arbois. Louis was greatly affected by her death, just as he was by his mother's. For months Louis mourned her departure, as is evident from a letter he wrote to his father on December 30:

> I am unable to keep my thoughts from my little girl who was so good, so happy and full of life, whom this fatal year now passing has taken away from us. She was just becoming a wonderful companion to her mother, to me and to all of us. But forgive me, my dear father, for recalling these sad memories. She is happy. We must think of those who remain with us and try as much as possible to keep from them the bitterness of life.

But in spite of his grief, Louis still worked endlessly on fermentation, trying to discover what made these tiny globules so powerful. Was he, he wondered, on the verge of explaining the reason for their power?

> I am pursuing as best I can these interesting studies on fermentation, connected as they are with the impenetrable mystery of Life and Death. I am hoping to make a decisive step very soon by solving, without any confusion, the celebrated question of spontaneous generation. Already I could speak, but I want to extend my experiments still further. There is so much obscurity, together with so much passion, on both sides, that I shall require the accuracy of a mathematical problem to convince my opponents by my conclusion. I intend to do even that.

So Louis wrote to Chappuis in January, 1860, the same month that he received the Academy of Sciences Prize for Experimental Physiology.

> God grant [he wrote a little later to his father] that by my persevering labors I may add a little stone to the weak and frail edifice of our knowledge of those impenetrable mysteries of Life and Death where all our intellects have so sorrowfully failed.
>
> P.S.—Yesterday I presented to the Academy my researches on spontaneous generation; they seemed to produce a great sensation. More later.

And there was much more later, as Louis went further into the subject, in spite of Biot's advice to leave the field to others. The whole discussion arose because many scientists believed animal life could be begun by outside

influences, rather than being born by other life, that it could be produced chemically, without the help of parent life.

Aristotle, back in the days of Greek history, began the long chain of unbelievable theories by saying life could be started by moistening a dry substance or drying a wet one. Virgil thought the carcass of a dead bull gave rise to bees, that mud would create frogs and fishes, and that leaves could produce caterpillars.

Later in the sixteenth century, a student named Van Helmont claimed he could create mice by simply putting a piece of dirty linen in a container with a piece of cheese or a few grains of wheat. Not long afterwards, an Italian asserted that a certain kind of timber, after being rotted in the sea, could make worms that would turn into butterflies and later into birds.

The entrance of the microscope onto the scene in the seventeenth century revived the wild theories, just as they were about dead. Students immediately decided the tiny organisms that appeared on the glass under the instrument, organisms that would multiply to a million within forty-eight hours, must be a result of spontaneous generation. They certainly could not, these men announced, appear that rapidly if they had to go through an animal process of birth or reproduction.

The opening gun of the battle in Pasteur's day was a paper sent to the Academy of Sciences by a correspondent of the Institute, M. Pouchet, director of the Natural History Museum of Rouen. The title was *Note on Vegetable and Animal Proto-organisms Spontaneously Generated in Artificial Air and in Oxygen Gas*. The gist of the paper was that "animals and plants could be generated in a medium absolutely free from atmospheric air, and in which, therefore, no germ of organic bodies could have been brought by air."

Louis secured a copy of the paper and underlined the parts which he intended to test by experiments. The whole world of science was discussing the subject. He wanted to get to the bottom of the matter. He did not know that he would spend four years of hard work to reach a conclusion that might not even then be correct.

Particularly, Louis did not believe Pouchet's statement that the air contained no tiny organs of life. To prove his belief, Louis passed air through cotton wool and collected particles which he tested and examined under the microscope.

Going over these experiments for a year, Pasteur announced: “Gases, fluids, electricity, magnetism, ozone, things known or things occult, there is nothing in the air that is conditional to life, except the germs that it carries.”

Louis had already written to Pouchet, suggesting that the scientist’s contentions might not be founded on fact, but Pouchet, now supported by M. Nicolas Joly and Charles Musset, would not be convinced. They maintained Pasteur’s results might have come from some compound in the wool itself, rather than from the particles collected from the air. He silenced this argument by conducting the experiment with asbestos.

Both Pouchet and Pasteur turned to vessels containing a liquid that would be affected by the organic or living germs. To test the air for these germs, the vessels were cleared of their original air by boiling the liquid, thus driving out the air, and then sealing the neck of the vessel. When the test was made, the neck of the vessel was opened, allowing the particular type of air to be tested to rush in. Then the neck was sealed again and the reactions of the air on the liquid observed. The liquid was so mixed that it would change if germs were present and remain unaltered if they were not.

Pouchet and his followers claimed that the air itself, its oxygen, would bring the new matter into being. Louis claimed, and proceeded to seek proof, that only the tiny living organisms in the air would cause the change and that pure air, air free from the dust that held these organisms, would make *no* change.

His opponents scoffed at the idea that clean and dusty air would affect the liquids differently. But he proved the theory to his own satisfaction by comparing the results of air on eleven bottles of liquid in the yard of the school with that on ten bottles of liquid of the air in the cellars of the Observatory of Paris where the temperature was invariable and the atmosphere undisturbed.

The liquid in the eleven bottles acted upon by the dirty outside air all showed a change, while only one containing the clean air from the cellars was affected. This proved to Pasteur that it was the globules carried by the dust rather than the oxygen that caused the change, that it was a change of reproduction of life, rather than a spontaneous generation.

At vacation time, he decided to make tests of other air to strengthen this evidence and planned another crusade in the interests of science, hoping to be able to have Chappuis go with him, but he was to be disappointed, as this letter written in August, 1860, shows:

> I fear from your letter that you will not be able to accompany me to the Alps this year. Besides the pleasure of having you for a guide, I had hoped to use your love for science by offering you the modest post of curator. It is by studying the air on heights far away from habitations and vegetation that I desire to complete my work on so-called spontaneous generation. The real interest of that work for me lies in the connection of this subject with that of ferments which I shall take up again in November.

Near Arbois, and not far from his father's tannery, along an old road, Louis Pasteur opened twenty of the seventy-three phials he had brought with him. Of these twenty, the liquid in eight showed a change, proving to Louis that the air near Arbois was purer than the air in Paris.

On Mount Poupet, eight hundred and fifty meters above sea level, only five vessels were altered out of the twenty tested.

September 20 found Pasteur at Chamonix, in Switzerland, hiring a guide for the ascent on the Montanvert. Next morning, the determined scientist picked his way precariously along the precipices, steadying the case of thirty-two flasks that rode on the back of a pack mule on the narrow path. Louis was not thinking of the danger of walking abreast of the beast on this perilous trail, instead of walking more safely behind. Those bottles had to be protected. Besides he had greater difficulties ahead of him.

The determined scientist picked his way precariously along the precipices.

In order to close again the flasks after taking in the air [he regretted in a report] I had taken with me a spirit lamp. The dazzling whiteness of the ice and snow in the sunlight was such that it was impossible to see clearly the jet of burning alcohol, and, moreover, as that was slightly moved by the wind, it never remained on the broken glass long enough to hermetically seal it. All the means I might have employed to make the flame visible

> and consequently directable would inevitably have caused error by spreading strange dust into the air. I was obliged, therefore, to bring back to the little inn of Montanvert, the unsealed flasks which I had opened on the glacier.

And Louis knew that he could take no chances in sealing up foreign dust in the vessels. Better to let the whole experiment be a failure—as it was because all the liquids changed—than to shield the flame with some device that would release dust different from that in the atmosphere of the mountainside. He knew every precaution had to be taken when testing the very air he was breathing. So that evening the guide was sent to Chamonix to have the lamp fixed in such a way that it would give a wider and larger flame.

Next day Pasteur made tests on twenty bottles that were to cause a great stir in the world of science. High on the mountain he laid the bottles out before him.

Taking up the first one, he drew a line with a steel tool around the pointed and sealed neck of the bottle, being careful not to cut it too deeply so that dust would enter into the liquid. Then he heated the pointed neck in the flame of his spirit lamp.

Raising the bottle high over his head to air that had not been disturbed by his own breathing or dirtied by his instruments, he cut the neck of the flask with long-nosed steel nippers that also had been heated in the flame to remove any dust they might have held and to burn any stray dust from the rough edge of the newly made cut which might be forced into the liquid by the onrush of air.

One by one the twenty flasks were opened and sealed just as soon as the air had a chance to rush in.

And of those twenty flasks, the liquid in only one changed!

In the dirty air of the city the liquid in each of ten bottles had showed a change. In the cellars of the observatory, fewer bottles had altered. Near Arbois, in the country, still fewer were affected, while, on the mountain, only one out of twenty had showed living organisms in the air.

> If all the results are compared [he wrote about the tests] that I have obtained until now, it seems to me that it can be affirmed that the dusts suspended in natural air are the exclusive origin and the necessary condition of life in the liquids in the vessels.

He might have added that this report should prove spontaneous generation impossible.

And in that report was another clue to his plans for the future: “What would be most desirable would be to pursue those studies far enough so as to prepare the way for a thorough research into the origin of various diseases.”

But the opposition that was to attack his later studies was also hinted at when he released his findings of the mountain trip. Pouchet insisted the tiny organisms were born of themselves out of the air.

Louis, undaunted, returned to his study of fermentation and made one discovery that was to bear on the spontaneous generation discussion. He discovered that some of these organisms could live without air, that air killed them slowly.

At that time, he made another try at being elected to the Academy of Sciences in the botany division, but it was not until the death of Senarmont that he was elected into the mineralogy division in 1862, and that not without opposition. Unfortunately, Biot had died earlier in the year and could not see his pupil finally receive the great honor, at the age of forty.

About this time, too, Napoleon III, the Emperor, asked to see Pasteur. As Louis’ oldest master, M. Dumas introduced him to the monarch. Napoleon was interested in science to some extent and followed this meeting with many others. Here again Louis dropped a suggestion as to the future when he said that all his ambition “was to arrive at the knowledge and the causes of putrid and contagious diseases.”

That summer Pouchet and two of his followers, Joly and Musset, staged their reply to Pasteur’s experiments in the mountains. On the Rencluse, a higher peak than the one used by Pasteur, they made their first experiments. But then they decided to go even higher and the thought of their future triumph gave them the courage to fight the fatigue and cold of a night in the open. In the morning they climbed across a rocky chaos and finally reached the foot of one of the Maladetta glaciers to begin their tests. Four vessels were opened, all containing a fluid made from hay, then sealed again. Arriving back at Luchon, their starting place, they noticed that the liquids in the flasks had changed and they triumphantly concluded that they were right, that life could begin from mere organic matter. Therefore, they believed, spontaneous generation was a possibility, was a fact, and Pasteur was wrong.

In November, Joly and Musset suggested to the Academy of Sciences that a commission be appointed to settle the question. The trial was set for the coming month of March, but Pouchet, Joly and Musset asked to have the trial set ahead until the summer, claiming the cold would affect their results.

Pasteur was slightly baffled by this request.

> I am much surprised [he said] at the delay sought by Messrs. Pouchet, Joly and Musset. It would have been easy with a stove to raise the temperature to a degree required by these gentlemen. For my part, I hasten to assure the Academy that I am at its disposal. During the summer, or at any other season, I am ready to repeat my experiment.

About this time a series of evening scientific lectures were being held at the Sorbonne. Public interest in the controversy over spontaneous generation having been aroused, it was but natural that Pasteur be on the program. On April 7, 1864, our Knight of the Laboratory stepped onto the platform in the large lecture room and as he did so he must have remembered the many times he had hastened to this same hall to sit at the feet of his idol, J. B. Dumas. The room was filled then but it was crowded now. The student, then, had now become greater than his master. Among those present were representatives of every plane of Parisian life. There were such celebrities as Duruy, Dumas the elder, George Sand, Princess Mathilde, the smart people of society, as well as humble students eager to drink in the words of their beloved master.

Many of those present had come because it was the fashionable thing to do, and they probably received an impression which lasted throughout their days. For the man on the platform was no seeker after praise and honor, but on his face were engraved lines which clearly showed how serious he considered his message to be.

> Great problems are now being considered [he began in a deep, firm voice] and every thinking man is in suspense; the unity or variety of human races; the creation of man a thousand years or a thousand ages ago; the fixity of the species, or the slow and progressive development of one species into another; the eternity of matter; the doctrine of an unnecessary God. These are a few of the problems that humanity is considering today.

Pasteur next explained the causes for the dispute over spontaneous generation, tracing its history and how the microscope had again brought the question to the forefront. He conducted an experiment on the platform which proved that germs and life must proceed from parents, from antecedent life.

> And, therefore, gentlemen [Pasteur concluded], I point to that liquid and say to you, I have taken my drop of water from the vastness of creation and I have taken it full of the elements favorable to the growth of inferior beings. And I wait, I watch, I beg it to reproduce for me the wonderful spectacle of the first creation. But it is silent, silent ever since those experiments were begun several years ago. And why? Because I have kept from it the one thing man is unable to produce, from the germs which float throughout the atmosphere, from Life, for Life is a germ, and a germ is Life. Never will the theory of spontaneous generation recover from the mortal blow of this simple experiment.

And as the speaker stepped from the platform and left the lecture hall, deafening applause thundered after him.

It was shortly after this speech that the three opponents of Pasteur who favored the theory of spontaneous generation agreed to allow only one flask to serve in settling the argument. This decision was announced, but the three immediately hopped on to the other side of the fence and demanded a whole series of tests. The commission refused to change the plan of demonstration, so the three withdrew from the contest and put their efforts to scaring up public opinion on the subject.

There was much talk about the theory of spontaneous generation's proving untrue the accepted religious beliefs. Someone talking to Pasteur asked him what did bring these tiny organisms and their parent organisms into the world. Louis' faith in God was never shaken throughout his scientific career. He answered this particular question with one word. That word was "Mystery."

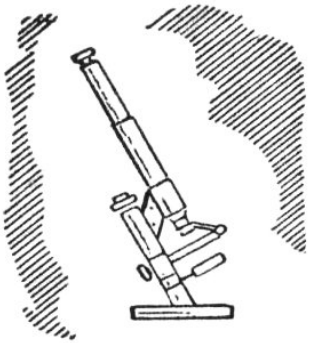
And even though Pasteur had used only scientific data in his discussions, many people accused him of being the defender of a religious cause. The novelist, Edmond About, wrote in an ironical vein: "M. Pasteur preached at the Sorbonne amidst a concert of applause which must have gladdened the angels."

Vainly had Pasteur proclaimed: "There is here no question of religion, philosophy, atheism, materialism or spiritualism." And later he added that it

was useless for science to try to interfere in the domain of the First Cause, in the realm of God. He maintained that religion did not interfere with science, nor science with religion. “Science,” he said, “brings man nearer to God.”

And that faith, that confidence, did not waver when the commission decided in his favor on the spontaneous-generation question and the decision was ignored by his rivals. Years afterwards, his three opponents’ experiments were finally disproved.

Louis was not worried about the subject. Another problem had come to his laboratory.



That summer, Louis Pasteur again turned his efforts to fermentation and especially fermentation appearing in wine. His native town of Arbois offered to pay all necessary expenses if he would study there and find the cause of the disease in their wines.

He found there was a sort of vegetable parasite that soured the wine, a germ whose death would leave the wine unspoiled. His researches eventually proved that keeping the wine at a high temperature for a few seconds when it was made would not affect the aging of the drink but would kill the ferment.

But prejudices of his enemies and those envious of him prevented the use of the cure, and French wine continued to grow worse when Dumas called Pasteur to the aid of another branch of French industry.

Pasteur's old master, Dumas, had been in his native town of Alais, a center of the silkworm industry, and had seen the tragedy that had fallen on more than thirty-five hundred of the proprietors of the silk industry. The riches that had sprung from the cocoons, one hundred thousand francs in one year, had been swept away by a disease called "pébrine" because the little black spots that revealed its presence resembled pepper. By 1864, the year before Louis was called to Alais, Japan was the only country left in the world where healthy eggs of silkworms could be found.

When Pasteur received Dumas' request for help he tried to decline. He said in a letter: "The object is a high one, but it troubles and embarrasses me! Remember, if you please, that I have never even touched a silkworm."

But, after reading a late report on the subject, he did agree finally to make the study in order to help Dumas.

Before reading the report, Pasteur did not even know that moths lay the eggs or seed from which the silkworms were hatched, that the worms fed on mulberry leaves, carefully nurtured on this tender diet until they shed their skins four times and finally spun their cocoons from fine material passing from glands in their heads. He did not know that these cocoons were put in hot water to kill the worm before it changed to a moth and cracked out of the cocoon, so spoiling the delicate house of the thread that was to be unwound again and spun into silk.

But after learning all these basic things, Pasteur went to Alais with one object in view—to find what caused the fatal black spots that affected the eggs or seed, the worm in the cocoon and even the moth.

When he reached Alais, in June, 1865, he questioned one native after another. They raised all sorts of theories, suggested all sorts of cures. Some treated the worms with almost everything from charcoal to sulphur. Others syringed the mulberry, on which the worms were fed, with rum, wine or absinthe. Another clan fumigated the worms with gas. Pasteur received all these ideas with sympathy and continued to question the cultivators. Where did the disease actually occur? And when?

This question seemed to be beyond answering. Sometimes the disease broke out in the eggs or seeds, sometimes in the moths; it came out in every stage of the process of silk production. For one or two steps, the trouble might disappear, only to pop out again when least expected. The silkworm nursery owners had about concluded pébrine could not be stamped out.

But Louis Pasteur went at the problem just as he had faced his crystals, just as he had finally silenced the cries of spontaneous generation. “Give me time,” was all he said as he went to work.

Others working on the disease had decided it was caused by tiny, microscopic corpuscles, of the same minute sort as moved in the ferments Pasteur had studied. To test the truth of the corpuscle theory, he immediately began to compare diseased worms with the sound, healthy ones he secured from Japan. But some of the moths producing the seeds would show no signs of the corpuscles under the microscope and yet give eggs that were infected.

Pasteur was no more than well started on his work with the silkworms when he received a telegram, stating that his father was very ill. He left for

Arbois immediately, in his third race to his boyhood home with death. He thought of the sudden deaths of his mother and of his eldest daughter, Jeanne, both of whom died before he could reach their side. "Now," he thought, "is this to happen again? Shall I be too late to see my dear father alive?" His fears were realized, for when he reached Arbois his father was already in his coffin.

That evening, Pasteur sat alone in the empty room above the tannery and penned this letter to his wife and four children who had remained behind in Paris:

> Dear Marie and Children:
>
> Your dear grandfather is no longer with us; this morning we followed him to his last resting place, close to little Jeanne's. In the midst of my sorrow I feel thankful that our little girl was buried there. . . . Until the very last I had hoped to see him again, to give him a last embrace. . . . But when I arrived I saw some of our cousins at the station, all dressed in black, arriving from Salins; then I knew, I understood that I could only accompany him to the grave.
>
> He died on the day of your first Holy Communion, dear Cécile; these two thoughts will ever remain in your heart, my poor child. I must have had a presentiment of it that very morning when he was struck down, when I asked you to pray for your grandfather at Arbois. Your prayers will have been accepted by God and perhaps your dear grandfather himself was aware of them and rejoiced with darling little Jeanne over Cécile's piety.
>
> All day I have been thinking of the marks of affection I received from my father. For thirty years I was his continual care and to him I owe everything. He it was who kept me from bad companions when I was young and inculcated in me thoughts of virtue, of religion and of work. Oh, he was far above his worldly position both in thought and in character. . . . You did not know him, dearest Marie, when he and Mother toiled so hard for the children they loved, especially for me, whose books and education cost so much. . . . How thankful I am that I could give him some satisfaction.
>
> Farewell, dearest Marie and children. We will often talk of Grandfather. How pleased I am that he saw all of you so recently and that he lived long enough to know baby Camille. I am anxious

> to see you all, but I must return to Alais, for my experiments would be kept back a year if I now remained absent for a few days.

After being delayed for a short time, hating to leave Arbois, temporarily settling his father's affairs, Pasteur hurried back to Alais, to the cocoons and corpuscles. He became convinced that the tiny organisms must be eliminated from every stage of the growth before the disease could be cured. He looked forward to spring when he could observe the next step in his crop of worms.

Already carrying a heavy burden of work, Louis Pasteur was laden down with another sorrow. He had no more than returned to Paris when his baby daughter Camille, two years old, fell seriously ill, so that for Louis each day's work was followed by a night of uncertainty and worry about the little girl. His days he spent at the laboratory and his nights at the bedside of his little daughter. He was able to lose his worry in work to some extent, especially in writing at Dumas' request an introduction to a life of Lavoisier, the scientist Louis had always so admired. But Camille grew no better. In September of that year, she died.

Pasteur again made that sad journey to Arbois, taking the tiny coffin with him. Death was claiming one by one those he loved best. A man of less strong faith might have rebelled against his Creator. But not Louis Pasteur. Back again he went to continue his work for humanity.

Shortly after his return, there was a serious outbreak of cholera in the city of Paris. Pasteur, Claude Bernard and Sainte-Claire Deville put forth their best efforts to get to the source of the disease, but the epidemic passed on before they could secure any definite results. All the while, there were the constant trips back to Alais to check on the silkworm industry.

At about that time Louis was invited by Napoleon III and the Empress Eugénie to spend a week at the Palace. He, of course, presented himself and was received at a great party the first evening. Present at the reception were M. de Budberg, ambassador of Russia; M. de Goltz, ambassador of Prussia; Dr. Longet, renowned for his *Treatise on Physiology*; Jules Sandeau, the novelist; Paul Baudry, the painter then at the height of his glory; Paul Dubois, the renowned artist of the *Chanteur Florentin*; Viollet le Duc, the emperor's favorite architect. It was a brilliant gathering, the ladies mirrored the height of fashion, the sparkle of jewels vied with the glitter of swords. One would almost think that there were no problems like silkworm maladies and diseased wines.

The Emperor, after greeting his guests, drew Louis aside and soon our Knight of the Laboratory found himself leaning against the mantelpiece, quietly instructing his sovereign on the causes of ferments and crystals. That evening, when the guests returned to the great corridor on which their rooms opened, each room bearing the name of a guest, Louis wrote to Paris for his microscope.

Next day there was a regal hunting expedition, for which Louis could not feel much enthusiasm. When a trip to see another of the palaces was organized for the following day, he made an appointment with the head butler to search the Emperor's wine cellars for diseased wines. He was a sight for the guests as he marched to his room, flanked by servants who wondered at this strange little fellow who so triumphantly hugged those bottles of spoiled wine.

For most of his visit, Pasteur appeared only when necessary. But he was always easily found—hunched over his microscope, studying a drop of sour wine.

On one occasion, Louis was summoned for a private interview with the Emperor and Empress. Arriving with his microscope, some other instruments and samples of sour wine, he instructed his sovereigns on the causes of spoiled wine. The Empress was very much interested and, asking Louis to follow her, she picked up the microscope and some samples of wine. Entering the drawing room where all the guests were assembled for five o'clock tea, she requested Pasteur to explain his theories while she laughingly assisted him with an experiment.

On another occasion, Pasteur was conducting an experiment for the guests of the palace during which live frogs were used. After the experiment Louis collected the frogs and placed them in a bag. But he forgot to take the bag with him when he left the room and that night the frogs had a merry old time, wandering through the palace, sitting on the Emperor's throne and one of them even found its way to the bedroom of the Empress, who did not notice her visitor and moving around in the dark accidentally stepped on the froggie's cold back—incidentally, she received quite a shock!

After his visit to the palace, Pasteur returned to Paris and was again requested by the Minister of Agriculture to return to Alais, which he did. Throwing himself into the work with all the boundless energy he possessed, he thought of nothing, day and night, except trying to relieve the suffering of these stricken silkworm cultivators for whom poverty was knocking at the door.

In order to be near her husband, Mme. Pasteur, leaving her son at school in Paris, started for Alais with her two daughters, Cécile and Marie Louise. On the way they stopped to visit Mme. Pasteur's mother and sister at Chambéry. They just arrived there, when Cécile, then twelve years old, was taken ill with typhoid fever. Mme. Pasteur, not wishing to alarm her husband and cause him to leave his work, simply wrote to him about Cécile's illness, stating that it was not serious. Nevertheless, Pasteur became alarmed after a few letters and rushed to the bedside of his daughter. The child, however, seemed to be on the road to recovery and, after spending a few days with her, Pasteur returned to Alais. But on May 23 a sudden relapse occurred and Cécile smiled for the last time at her little sister Marie Louise—that smile that had so much charm, that lighted up her usually serious face, was quieted forever. Pasteur again arrived too late at the side of one of his dear ones. He took the body to Arbois, where it was laid to rest alongside of the other dear departed members of the Pasteur family.

In writing from Chambéry to her son in Paris, Mme. Pasteur said: "Your father has returned from his sorrowful journey to Arbois. I thought of returning to you, but I could not leave your sad father to go back to Alais alone after this great sorrow."

Again Louis had to try to forget personal bereavement by losing himself in his work. That work was still the study of the silkworm. At last he had conclusions to report.

He had found that the trouble was not really a disease but an outgrowth of the regular life of the worms and moths. Before, all had thought the seed or the worm had been the cause of the spread of the trouble. Louis found with his microscope that cocoons just about to release the moths brought about the greatest damage when they were unhealthy.

In a letter to the Minister of Public Instruction, he described his proposed method of curbing the difficulties:

> What happens is this: you have a crowded nursery which promises either success or failure; you are not certain whether you should smother the cocoons, or whether you should keep them for reproduction. Nothing could be simpler. You take about a hundred moths and hasten their development through an elevation of temperature and you examine these moths through a microscope, after which you will know what to do.

> Under these circumstances the unhealthy symptom is so easy to detect that a woman or a child could recognize it. If the cultivator is a peasant, who lacks the materials necessary for this treatment, there is an alternative; let him keep the moths until after they have laid their eggs, bottle a good many of them in brandy and send them to a testing office or to some experienced person who will determine the quality of the seed for the following year.

But his suggestion to throw out all seed from infected moths so that they would not spread the trouble was not taken kindly by his opponents. That would mean throwing out a good share of the eggs that were produced. Some better way should be found. This talk of minute organisms infecting eggs and spreading infection was the idea of a lunatic.

Pasteur proved that the trouble could be spread quickly and easily by feeding worms mulberry leaves that had been painted with the pébrine. But the proof was not accepted, so Pasteur waited patiently until a vast number of eggs he had prepared by his methods would come to maturity. Waiting for the silkworm season, he returned to the study of wines. He was sure he had gotten to the roots of the silkworm malady.

But would the eggs come out properly?

He tried to forget them as he busied himself with sour wine, with another disease that was ruining French industry.

Chapter IX Wine

Millions of francs were invested in the French wine industry—and were going overboard just as was the money behind the silkworm business. French wines were losing their place in international commerce because they were turning sour and acid before they could be properly aged into flavor.

Of course, the microscope was Louis Pasteur's first tool in digging into this problem. Although he had previously recommended heating to cure the trouble, he began a thorough study of the various beverages to discover the different kinds of little organisms that made up the fluid and that affected its health.

He managed to classify the kinds of these minute living particles and state what ill effect they had on the wine.

The next problem was to find a way to prevent these particles—or bacteria, as they are called—from affecting the wine. This task was not an easy one. The taste of the wine had to be thought of, just as when water is purified; chemicals cannot be used that would spoil the flavor. In France, wine appears on the dining table almost as often as water, so that the entire nation could detect almost the slightest difference in taste in the beverage.

Pasteur tried a number of different compounds and solutions that might kill or injure these damaging bacteria, but all altered the taste of the wine. At last he had to resort to heating.

He found that a slight amount of heating of wine sealed from the air would result in success. Bringing the liquid to about fifty-five degrees centigrade—well below the boiling point—for a few moments made the organisms harmless and did not change the flavor of the wine.

To test his process, Pasteur offered wine that had been heated by his process and wine that had been left at the same temperature to men who were judges of fine wine. They could find no difference in the two liquids, either in their flavor or their bouquet (odor).

But Pasteur was not satisfied with this opinion alone. He wanted official approval and acceptance of his method, so he suggested that a commission of important wine merchants be assembled to test the treated wine and compare it with the untreated.

This commission was appointed and met at the École Normale, announcing that, if any difference in the two wines' taste or bouquet did exist, it was too small to notice.

Here was Pasteur's first step in the important field that now bears his name. The studies and methods spread to other liquids, but the foundation was laid for pasteurization when Pasteur made this conclusion about wine.

Soon he published a book, *Studies on Wine*, which covered this research and explained the process so that anyone in the industry could make his wine properly. Pasteur dedicated the book to the Emperor and also acknowledged the help of General Fave in bringing the author's work on wine to the Emperor's attention. Fave, out of modesty, stating that he had done but little, refused to allow his name to be included in the book but came to be a useful friend to Pasteur in later works.

Even during this time when praise for his book and his aid to the French wine industry was coming his way, Pasteur still had opposition on every hand. The spontaneous-generation crowd was heard from again. Pouchet, his former rival on the subject, now turned to working against him on the silkworm disease.

But Pasteur was waiting anxiously the silkworm season. When he went to Alais early in 1867, two years after he had begun the work on the malady, he was sure he had found the cure. He needed only to have the actual proof from the cultivators to whom he had distributed seeds he believed to be healthy. If these seeds produced healthy worms, he would know that his isolation of the disease was successful and that he could soon stamp out the whole trouble.

As he waited patiently, the letters from these various cultivators drifted in. If only they would all report healthy worms!

But he said little as more of these letters filtered in. A doubt crept into his mind. Perhaps his method was not right after all.

But no. That could not be so. He had proved it to his own satisfaction the fall before. Some other force must be killing these worms.

A little study convinced him of the fact. The worms did not show the peppery spots. Instead they turned all black when they died. And they showed no signs of the corpuscles that he had learned to expect in pébrine. Yes, there must be something else.

And he was sad, almost discouraged, as he announced to his assistants, who had accompanied him to Alais:

“Nothing has been accomplished. There are two diseases.”

The eggs were free from pébrine, but, under the microscope were signs of flacherie, another silkworm disease. There was nothing left to do but be ready with another set of eggs for cultivation the next spring.

In May, Louis Pasteur received word at Alais that a grand prize medal of the 1867 exhibition was conferred on him for his *Studies on Wine* by the judges of the Universal Exhibition. He suspected Dumas had something to do with the prize and wrote to him in appreciation:

> Nothing has surprised me more—or so pleasantly—than the news of this Exhibition prize medal, which I never expected. I look upon it as a further proof of your kindness, for I feel confident that your suggestion was responsible for originating such a favor. I will do all I can to show my worthiness of it by persevering in spite of the difficulties of the problem which I am studying, and which is becoming clearer every day. The appearance of the flacherie disease greatly complicated my investigations, which would otherwise have been satisfactorily completed by now. I cannot now explain how certain I am that my conclusions concerning the corpuscle disease are correct.

Pasteur immediately went to work with his microscope, studying the moths in order to secure eggs that were healthy, free from both pébrine and flacherie. He set up a large number of eggs that were not diseased and also a diseased group, which were for comparison the following spring.

Many of the cultivators in the region had begun to have faith in his methods and set out only healthy eggs for cultivation, as they had the previous year.

In July Pasteur again went back to Paris, this time to receive, in all the splendor of speeches and bright flags, the Universal Exhibition medal which had been awarded him in May. One observer described him, remarking: “I was struck with his simplicity and gravity; the seriousness of his life was visible in his stern, almost sad eyes.”

Trouble of a political sort broke out at the École Normale that finally resulted in Pasteur’s being recommended as Inspector-General of Higher Education, while Balard applied for the same post. Pasteur immediately withdrew in favor of his old master.

Politics were forced into the scientist's life, however, when he sought better laboratories for himself and other scientists in France. Much agitation arose on the subject until, with the help of Duruy, Minister of Public Instruction, and General Fave, Napoleon III ordered a laboratory built for Pasteur, to be used by him and his pupils as a model. The site was to be part of the garden at the École Normale.

At this time, Pasteur was called to Orleans for a lecture on the making of vinegar, which he had studied, as it was largely similar to the manufacture of wines. He was greeted at the lecture by scientists, manufacturers of this product, so important in Orleans, and even ladies. His talk was accepted with great appreciation, as the men in the industry soon could see how the facts he gave would save them millions of francs. His closing words expressed his attitude toward research and explained his endless working on what seemed to most men impractical, dreamy studies:

"Nothing is more agreeable," he said, "to a man pledged to a scientific career than to increase the number of discoveries, but when the result of his conclusions is demonstrated by practical usefulness his cup of joy is filled."

When Pasteur returned from Orleans, he soon found politics standing in the way of his new laboratory. The appropriation had been refused; but he donned his fighting armor and began his crusade anew, this time in magazines and on the lecture platform.

"Physicists and chemists without laboratories are like soldiers without arms on a battlefield!" he exclaimed.

Napoleon III at last gave his full support to the plan, and the laboratory was assured. It had been a long fight, but French science was to benefit from the victory.

A new test was devised then for Pasteur's studies on wine. The Minister of the Navy had been long troubled with keeping wine properly, without spoiling, on long ocean voyages. The Pasteur method of preserving wine was suggested to him. He contacted Pasteur and stated he was going to load a ship, destined for a world cruise, with wine Pasteur had treated by heating, and a ship bound for West Africa with a small portion of unheated wine.

As Pasteur predicted, the ship made the world cruise without the wine's spoiling, while the ship sailing to the west coast of Africa had trouble with its cargo.

It was a tired Louis Pasteur, worn with many and constant activities, who was planning the next spring's work on silkworms, while lecturing at the Sorbonne in Paris.

On the nineteenth of October, 1868, he felt a strange prickling along his left side, was even kept from working after lunch by a violent attack of shivering. But he was scheduled to read a paper later at a meeting and insisted on going, in spite of his illness.

After the meeting, he managed to get to his flat all right, and into bed. Then it was that he was stricken with a recurring paralysis. For a while he would have control of the muscles on his left side. Then he would be able to move none of them. Doctors, coming immediately, feared he had not long to live.

For a week he was on the verge of passing away. Great men of science and the Government visited the Pasteurs' flat in the École Normale constantly. The emperor asked that daily bulletins be brought to him.

All during these critical seven days, when Louis Pasteur felt that he might not again see his laboratory, his mind was alert. Whenever he was able to talk, he discussed his work. One evening a scientist keeping watch at Pasteur's bedside tried again and again to divert his mind from work, but could not do so. Finally he took down all Pasteur said and showed the notes to Dumas in the morning.

Dumas was astonished with the results. In the notes was a formula for discovering the silkworm eggs that contained flacherie, a set of practical, clear directions from a man who had been paralyzed for a week! It was almost too much to believe.

Slowly, painfully, Pasteur regained the use of his muscles that were, however, never to return to their original efficiency. In January he insisted on going to St. Hippolyte le Fort, near Alais, to resume his silkworm work, in spite of his difficulties. He was permitted to go to this strenuous task only because he was so unhappy away from it.

Dumas wrote to him and received this answer:

> MY DEAR MASTER: I thank you for remembering the poor invalid. I am in almost the same condition as when I left Paris, my recovery having been retarded by a fall on my left side. I sustained bruises, which were very painful, but fortunately no fracture.

No traces of the accident now remain, and I feel about as I did three weeks ago. The improvement in the movements of the leg and arm seems to have begun again, but very slowly. I am about to undergo electric treatments, under the advice and instructions of Doctor Godelier, who has sent me a small Ruhmkorff apparatus for that purpose. My brain is still very weak.

I spend my days in the following manner: In the morning, my three young friends visit me, and I arrange the work for the day. I rise at twelve, after having my breakfast in bed, during which time the newspaper is read to me. In short, I then spend an hour or so in the little garden of this house. As a rule, if I am feeling strong enough, I dictate to my dear wife a page, or more often a half page, of a little book I am preparing and in which I intend to give a short summary of all my observations. Before dinner, which I take alone with my wife and little girl, so as to escape the fatigue of conversation, my young collaborators present me with an account of their work. About seven or half past I always feel very tired and am ready to sleep twelve consecutive hours; but more usually I wake at midnight, and do not sleep again until toward morning, when I doze for an hour or two. What makes me hope for an eventual cure is the fact that my appetite remains good, and also that the few hours of sleep I have seem to be sufficient. You will understand by this that I am not being rash, apart from being watched closely by my wife and little daughter. The latter pitilessly removes books, pens, paper and pencils out of my reach with a persistency that causes me joy and sorrow. . . .

Now the silkworm season was reaching its heights, and Pasteur's opportunity to prove his conclusions to the skeptical ones was ripe. The Silk Commission of Lyons thought his methods might be useful but not overly practical. Pasteur replied, "They are absolute," and had the chance to stand behind his words when the Commission asked him to provide eggs whose health he would personally guarantee.

To make the job complete, he submitted four kinds of seeds to them. One healthy lot that would produce healthy worms; one that was corpuscled and would produce pébrine; one from which the worms would die of the flacherie disease and a fourth that would show both pébrine and flacherie.

He could have convinced the Commission if the first set of eggs, the healthy ones, had hatched out successfully and free from disease, but he was

not satisfied to do the job scantily. He wanted to demonstrate how much science could do for French industry.

And his demonstration convinced the Commission entirely. Each of the four sets of eggs came out just as he had predicted. His victory over the two diseases was strengthened by the fact that the cultivators to whom he had sent seed the preceding fall all had good results, healthy silkworms.

Of course, jealousy developed from Louis Pasteur's success. The unscrupulous seed dealers who sold seed to peasants and cultivators without caring whether it was healthy or not resented his instructing the users to buy only healthy seed and to have their seed tested before buying. Today, in America, we would call these men racketeers.

The Government, for political reasons, hesitated to give Pasteur's procedure official sanction and so left him without the support that would have carried much weight against his opponents. The Government continued to waver back and forth on the issue until Marshal Vaillant, an admirer of Pasteur and Minister of the Emperor's Household, stepped into the picture.

He arranged that Louis Pasteur and his wife, son and daughter should move to a property belonging to the Imperial Family, the Villa Vincentina, near Trieste, where a fine silkworm nursery had decayed to nothing. Vaillant figured Pasteur's visiting there would serve two purposes, bring the property back to usefulness and call to the Government's attention just what could be done by his handling of pébrine.

The easy life did help Pasteur to regain strength and also won him his point. His pamphlet, that developed into a two-volume work, *Studies on the Diseases of Silkworms*, was well received.

Already in his career, Louis Pasteur had restored to security the silk industry, the wine industry and aided the vinegar industry, a full achievement for any one man's lifetime.

But not for Pasteur. There was much to come. Trouble after trouble to be faced.

Chapter X War!

By 1870 Louis Pasteur, at the age of forty-eight years, had faced tragedy again and again. Especially the last few years had seemed to pick him out as the victim of one great sorrow after another. The death of his father, of two of his daughters, and finally the paralysis that had taken so much of his strength and would be a burden for the rest of his life.

Rivals, envious scientists, had contradicted the results of his experiments, caused him constant work in trying to answer the objections of those men who were clearly prejudiced against him. Circumstances on every side had made his successes all the more praiseworthy because they had been accomplished against great odds.

Now another blow was to fall, one that was to turn Pasteur bitter for a time, one that was to drive him from his laboratory, one that was to cause national pain and suffering—and finally was to wrench from its wreckage a great discovery by Louis Pasteur.

War was far from the thoughts of France at the beginning of the year 1870. She believed she had an ideal relationship with Germany, an agreement by which the two nations would advance science and the arts and, above all, further the cause of peace among all the nations of Europe. Louis Pasteur believed in that situation, worked all his life endeavoring to advance science to the point where it would bring about international relationships of good will and peace, break down natural barriers of enmity, by an interchange of discoveries benefiting all humanity. That was part of his aim in fighting for better laboratories, for better conditions, Government aid for all research workers.

That dream, that ideal state was crushed violently by Bismarck and Prussia, who trapped France into war in July of 1870. And Pasteur, already working against great obstacles, stumbled under the heavy weight of this new disillusionment. His dreams were shattered. His beloved France was soon to fall in horrible defeat, in disorganized panic, before a nation suddenly insane with cruelty. He was to see hospitals shelled, women and children shot, laboratories wrecked or burned. Worst of all, he was going to see France's Government fall beneath another revolution, beneath civil war. He was going to see the national spirit all but disappear.

Returning from a visit to a prominent adversary, Liebig in Germany, and having that scientist refuse to listen to his arguments, that decomposed matter was not necessary for fermentation, Louis Pasteur stopped in Strassburg to renew old acquaintances for a short time. When he was leaving, two days later, the blow had fallen. War was a certainty. And Pasteur knew France too well to expect a victory. He knew the weaknesses in her system and the lack of fire in her leaders. He knew defeat was coming, but even he did not realize the carnage that was to follow.

The student body of the École Normale enlisted to a man, just as did the sons of Bertin, Sainte-Claire Deville and Pasteur's only son, who was then just eighteen years old. The school was turned into a hospital.

Louis Pasteur himself had voluntarily served in the National Guard in 1848, and, in spite of the fact that he was now twenty-two years older and partially paralyzed, he followed his father's teaching and offered himself for military service. Of course, he was refused.

He then wanted to stay in Paris to help in every way he could. Here again he was refused. After the amazing number of defeats dealt out to the French troops since July, there seemed to be no doubt but that the Prussians would soon be in Paris. Louis Pasteur was urged to leave the city, as were all other nonfighters.

So back to Arbois where there were no laboratory facilities, in case he had been able to tear his mind away from the national pain enough to work. He tried to satisfy himself with reading, but he could never resist rushing from the house when the war news was announced in the main street of the town, news that was always the same, except when it was more disheartening.

Louis Pasteur's history through the rest of the war was a series of bitter, discouraging events. He replied to Prussia by sending back a diploma bearing an honorary degree from the University of Bonn and carried on caustic correspondence with the principal of the institution. One of Pasteur's letters gives us an insight into the depth of his feeling:

> And now, Mr. Principal, after reading over both of our letters, I sorrow in my heart to think that men who like yourself and myself have dedicated a lifetime to the pursuit of truth and progress, should address each other in such a manner. . . . This is but one of the results of the character your Emperor has imparted to this war. You speak of taint. Mr. Principal, taint will rest, you may be

certain, until far into the future, on the memory of those who began the bombardment of Paris when capitulation by famine was inevitable, and who continued this act of savagery after it had become evident to all men that it would not advance by one hour the surrender of that heroic city.

Louis Pasteur's dreams for his beloved France were shattered. War was a certainty.

In short, Pasteur felt that one of the greatest losses of the war was that the scientists of the two countries, who should have been working together for the benefit of humanity, were enemies, kept apart by brutal fighting brought on by the politically ambitious.

In the latter part of January, 1871, Pasteur had had no word from his son for quite some time. The young man was serving in the Eastern Army Corps, in action near the town of Hericourt. Pasteur heard rumors that this section of the army was in bad shape and had suffered tremendous losses, so he became quite worried and determined to go in search of him.

So on Tuesday morning, January 24, together with his wife and daughter, Pasteur set off in an old rickety carriage to find his son. Saying good-by to Jules Vercel, his old boyhood friend, Louis Pasteur proceeded through the snowbound countryside in the direction of Pontarlier. On the road they met many pitiful-looking soldiers, in disordered rout. Many of them lost, begging for bread along the way, and only the shredded rags of uniforms covering their almost frozen bodies.

Arriving at Pontarlier on Friday, their carriage practically a wreck, the Pasteurs found the town full of destitute soldiers. Some were crouching around fires, others begging for a little straw, a few were trying to bandage frozen feet before gangrene could set in.

Searching for his son, Pasteur met a staff officer who was a nephew of Sainte-Claire Deville, and said, “The retreat from Moscow could not have been worse than this.”

Meanwhile Mme. Pasteur anxiously questioned soldier after soldier as to the whereabouts of her boy. But no one seemed to know anything definite about her son’s battalion of Chasseurs. One of the answers she received was, “All that I can tell you is that out of twelve hundred men in that battalion there are but three hundred left.”

She did not give up hope, however, and clasping her daughter tightly by the hand she kept on.

“Sergeant Pasteur? Are you looking for Sergeant Pasteur?” asked a soldier who was passing by and chanced to hear her inquiries.

“Yes! Yes! I am. Can you tell me anything about him?”

“He is alive,” said the soldier. “I slept by his side last night in Chaffois. He remained behind because he was ill. No doubt you can find him coming along the road leading to Chaffois.”

“Louis, Louis,” called Mme. Pasteur to her husband. “Come quickly. Our son is alive and is on the road toward Chaffois. Let us go to meet him.”

Just a short distance from the gate of the city the Pasteurs saw a cart coming toward them. In it was a soldier huddled in his coat. Upon seeing the searching party, he started suddenly and leaped from the cart and ran toward them. And there on the snow-covered road between Chaffois and Pontarlier the Pasteur family was reunited without saying a word, so deep was their emotion.

The Eastern Army Corps was entirely disorganized, without food, without clothes and even without arms; the soldiers were instructed to cross the border into Switzerland, to seek refuge there. Pasteur accompanied his son to Geneva. After recovering his health there, the young soldier joined his reorganized battalion in France during the early part of February.

The war was soon over. France was crushed. After its termination, Louis Pasteur tried to begin a study of a new phase of his crystals, but the socialists’ revolt stopped him. He had no place to turn and was sorely tempted to accept an offer to go to Pisa and help the Italians with their silkworms. After much correspondence, he finally decided not to forsake France when she most needed help.

Still, Paris was in an upheaval and the Germans occupied Arbois. Pasteur visited various of his friends, waiting impatiently till the time when he could return to his laboratory.

His loyalty to France persisted, in spite of her disorganized Government, in spite of statesmen with selfish thoughts and in spite of officials who had more than once treated him unfairly and whom he blamed for the nation’s collapse. This was typical of Louis Pasteur’s whole attitude toward life. He was a Frenchman. He had been born and raised on French soil. It was his duty to stand by his nation in time of need, even though it meant giving up the Italian venture that would have been much more pleasant and much more profitable.

Casting around for a way he could help France by helping her industries, Pasteur settled on another field where his study of fermentation could be utilized. Perhaps there was still a remnant of revenge in his mind when he decided to work on French beer so that it could compete in the world’s markets with German beer, which was acknowledged as the best. Perhaps he wanted to win, in his laboratory, a victory over a country France could not best on the battlefield.

Pasteur picked a small brewery at Chamalières, between Clermont and Royat, as his study case. And he soon found how little the brewer there, or any of the brewers in France, knew of the manufacture of beer or of its chemical structure.

He also studied a pamphlet dealing with the subject, issued by one of the members of the Institute. The paper told how beer was made. How barley malt was diluted, then heated and mixed with hops to form what was called the beerwort, the wort that was cooled and fermented by adding yeast to make the final product. The trouble with French beer in general, according to M. Payen, arose in the summertime when the beverage was changed chemically. "It becomes acid," he said in an article, "and even noticeably putrid, and ceases to be fit to drink."

Pasteur, after some study in a general way, decided to get to the cause of the spoiling before he tried to find a cure. He was certain that beer became rank in much the same way as wine—by the effect of germs in the air, in the water or on the utensils used at the brewery. He figured it was again a case of foreign living organisms, visible only through the microscope, that affected the normal actions of the manufacture and turned the product sour.

The small brewery at Chamalières was soon outgrown by the experiments, and Pasteur, still limping but with his shortsighted eyes shining with that fire of energy, presently introduced himself to the managers of great breweries in London.

One of the managers was showing him through the plant when Pasteur asked for a sample of the barm or foam off porter beer which was passing through a trough near by. He immediately placed this sample under the microscope and found harmful ferment in it. "This porter must leave much to be desired," he said to the manager, who was temporarily dumb with surprise.

Pasteur suggested that perhaps the yeast had left a bad taste in the porter, and the manager had to admit a complaint he had received only that morning. Putting new yeast under the microscope, he found it much purer and producing a much purer brew.

The owner of the brewery was quite humiliated when Pasteur accused him of impurities in one beer after another, as he placed them under 'scope. Some showed diseases well started, others a threatening trace. The owner stood open-eyed, not quite knowing what to answer this man of science from a foreign country who sat criticizing his beer.

Yet there was the ring of sound judgment in Pasteur's words as he explained his conclusions: "Every marked alteration in the quality of the beer coincides with the development of microorganisms [microscopic particles] foreign to the nature of beer yeast." And the owner of the plant began to listen more carefully and respectfully.

In fact, when Pasteur returned to the same brewery about a week later, the owner had installed a microscope, had put in all new yeast and had ordered every bit of yeast put into process to be tested.

When Louis Pasteur returned to Paris, he had the pleasure of having Bertin, his old school friend who had become a subdirector of the École Normale, as a companion. Bertin, always gay and full of jokes, often dropped in on the Pasteurs, who lived on the same floor, and did much to lighten the determined little scientist's days and evenings. Pasteur kept on with his work on beer until he proved his original assumptions correct—that beer was spoiled by tiny organisms or germs that came from the air, the water or the utensils used in brewing. He then set about correcting the trouble by heating the bottled beer to a temperature of about fifty to fifty-five degrees centigrade, just as he had with wine. This was the first time this heating process had the name of *pasteurizing*.

The subject was discussed in a book written by Pasteur that also contained this paragraph which pointed the way for future scientists and gives a glimpse of the part science was to play in the years to come:

> When we see beer and wine subjected to deep alteration [spoiling] because they have given refuge to microorganisms invisibly introduced and now swarming within them, it is impossible not to be pursued with the thought that similar facts may, *must*, take place in animals and in man.

As always, Pasteur's discovery met with new arguments. And besides, the spontaneous-generation addicts and his rivals in the field of fermentation and silkworms were doing their best to talk down the facts proved in his laboratory. Just as always, Pasteur had to spend precious time silencing their objections, while keeping up with his work on ferments.

However, these arguments, tiring and wasteful as they were, served to strengthen Pasteur's proof that ferments are living beings that are bred from other living organisms and not started without the aid of parent ferments. He was fighting to establish the facts that he would soon use in an attempt to

release the world from needless disease, that he would soon use to expose to the light the theory he had been considering for years.

Could he convince the world of science of the strength of these tiny microorganisms? Could he make scientists understand how these little beings caused disease? Or would he be considered a fool and branded a useless dreamer?

All through Louis Pasteur's scientific life to this time, one idea kept hammering at the back of his mind. All his studies for French industry, the work on ferments in general, on wine, on beer, on the silkworm disease pointed out to him a theory that he could not ignore.

As he discovered and studied each of the tiny organisms under the microscope, he became more curious as to their relation to living animals and humans. He saw these little particles in wine and in beer, doing their work of fermentation, multiplying to greater numbers every hour. He knew fermentation could be caused by little bodies in the air that were invisible to the naked eye but able to produce tragic consequences.

Lister, an English doctor and hospital head, had done much to bear out Pasteur's theories on the subject. One of Pasteur's deepest admirers, he had worked day and night to put many of the celebrated French chemist's ideas into practice. He, too, believed that the little rods and globules to be seen under the microscope were to blame for many of the unexplainable mysteries of both chemistry and medicine.

And Pasteur, along with his deep and unselfish love for his fellowman, had personal reasons for probing into the world of medicine and doctors. Had he not lost members of his own family through contagious disease, through unsanitary methods of doctors?

Did he not know what it was to live without the children who had become so dear to him, who were his own flesh and blood? If only he could find a way to prevent so much of this pain in the world! If only he could aid

the doctors to find the causes and cures for these dreaded diseases and epidemics! If only he could have saved the lives of many of those young men who had died of wounds received during the war with the Prussians, who had died of infections developed in the hospitals where they had gone with hopes of being cured!

Pasteur saw an opportunity to break into medical circles, where he could advance his theory of the relationship between germs and contagious diseases, when an opening developed in the section of Free Associates of the Academy of Medicine. He immediately stood for election into that body and won by the bare margin of one vote.

It was on a Tuesday in April, 1873, that he attended the first meeting, a serious, quiet man, whose left leg still dragged a trifle as he made his way to his desk.

Now that he was admitted into such a group, he believed that his discoveries, his lectures, would be accepted by the members and used to save human and animal life. But his hopes were soon blasted. Doctors considered themselves great men whose methods were not to be questioned by a "mere chemist." Many were convinced in their own minds that there could be no connection between a chemical fact and the human or animal body. Chemistry was one thing. Life another.

Pasteur tried to prove to the Academy that the tiny organisms or germs could cause disease, could cause ferment in animal life, as well as in wine or beer.

Speaking before the group on this subject, he closed his remarks with these words:

> The Academy will allow me to make one last remark. It must be owned that those who contradict me have been rather unfortunate in taking the occasion of my paper on the diseases of beer to renew their arguments. And my work on beer, entirely based as it is on the discovery and knowledge of certain microscopic beings, has it not come after my studies on vinegar? Has not that work been continued by my studies of the causes of wine diseases and the means of preventing them, still based on the discovery and knowledge of microscopic beings? Have not these last results been followed by the discovery of means to prevent the silkworm disease, equally deduced from the study of nonspontaneous microscopic beings?

> Are not all the researches which I have followed for seventeen years, at the cost of many labors, the results of the same ideas, the same principles, pushed on by unceasing toil into conclusions ever new? The best proof that an investigator is following the right course is the uninterrupted fruitfulness of his work.

But even though every new fact Pasteur presented seemed to be met with the greatest of opposition, some of the more progressive members listened to his ideas, took him to their hospitals so that he might be able to see conditions and the pitiful need for help. Here again Pasteur saw more and more reasons why his teachings should be applied to medicine—or at least be given a fair trial.

The doctors in general blamed infection and most disease on some strange, unknown force, acting from within the animal or human, some result of life that made the body ill. Pasteur maintained infection and disease were brought to the body from outside in the form of germs, tiny particles that floated in the air or were carried to the patient through the doctor's instruments or hands.

Pasteur, like men and women today, could see no reason why, when no other means could effect a cure, the doctors would not try his methods. In France in Pasteur's day, going to a hospital practically amounted to committing suicide. One surgeon admitted that "a pinprick is an open door to death." And, visiting the hospitals, Pasteur knew this surgeon was not far wrong. The pain, the suffering, the hopelessness of the patients was a sight almost too sorrowful to bear. Could nothing be done to stop this unnecessary death?

Pasteur felt encouraged when he received a letter from his friend Lister in February of the following year.

> Allow me to beg your acceptance of a pamphlet I send by the same post, containing an account of some investigations into the subject which you have done so much to elucidate, the germ theory. . . . I flatter myself that you may read with some interest what I have written on the organism which you were the first to describe. . . .
>
> I do not know whether the records of British surgery ever meet your eye. If so, you will have seen from time to time notices of the antiseptic system of treatment, which I have been laboring for the past nine years to bring to perfection.

> Allow me to take this opportunity to tender you my most cordial thanks for having, by your brilliant researches, demonstrated to me the truth of the germ theory of putrefaction [infection or rotting], and thus furnished me with the principle upon which alone the antiseptic system can be carried out. Should you at any time visit Edinburgh, it would, I believe, give you sincere gratification to see at our hospital how largely mankind is being benefited by your labors.
>
> I need hardly add that it would afford me the highest gratification to show you how greatly surgery is indebted to you.

This letter was written in English, as was the accompanying pamphlet. Pasteur was not so familiar with the English language as he was with the German and, although able to read and understand the letter, he had a friend translate the entire pamphlet for him.

After reading the pamphlet, Pasteur knew that at last someone had made a sincere application of the principles for which he was fighting. Dr. Lister believed in Pasteur's teaching that germs did spread diseases and that germs did enter wounds and cause infections by means of unsanitary instruments, hands and air.

Lister's system demanded that every element touching the patient's wound be thoroughly cleansed of germs. Every instrument, bandage, human hand was passed through a solution of carbolic acid. The wound was washed with a similar solution and the bandages prepared very carefully. A gauze tent or shield treated with paraffin was erected around the wound to purify the air in its vicinity.

This treatment had met just such complaint and opposition as had Louis Pasteur's work in France, but the evidence of the effectiveness of the idea eventually convinced Lister's enemies. Germany was the first to look on the system favorably.

Lister's finishing argument on the subject was a record of forty amputation cases. In the days of the Franco-Prussian War, having a limb removed usually took the life of the patient. Few of the injured soldiers who were forced to have such an operation survived. Lister, however, with his method treated forty amputation cases with the loss of only six patients.

Pasteur immediately saw how valuable Lister's work might be to French doctors and to his own campaign to drive disease and contamination from the hospitals. He studied the English doctor's method thoroughly and

presented the pamphlet inclosed in Lister's letter to a number of Paris physicians.

Reporting, he wrote this letter to Lister two weeks later:

> I have been delayed in answering your wonderful letter of February 10. Do not think this was from indifference but quite the opposite. I received the greatest satisfaction from your letter, and I at once requested one of my friends who knows English to translate the pamphlet which you so kindly inclosed with it. I had indeed been informed of your antiseptic treatment by the same friend, who is chief surgeon at the Val de Grace, and Tyndall has told me of the wonderful success of your surgical practice, but I must confess to my sorrow that I know very little about your work, although I have long desired to become better informed. The contents of your pamphlet have made me more impatient and regretful. I am greatly surprised at the exactness of your methods, at your thorough grasp of the experimental method, and I find it difficult to comprehend how you can undertake researches which take so much care and time while you also devote yourself to the profession of surgery and even that of chief surgeon in a great hospital. I do not believe there is a similar instance of such a person among us here.
>
> I have discussed both you and your letter with my illustrious friend, M. Dumas, permanent secretary of our Academy of Sciences. M. Dumas expressed his wish, to which I add my own, that you would have the goodness to send him a full account of your antiseptic system for communication to the Academy. I have discussed your methods with some very able surgeons; they certainly know of them and some even have adopted them, but they have only a partial knowledge of this question, and you would perform a service to French surgery and to your friends by acceding to M. Dumas' request.

After writing this letter, Pasteur started an intensive campaign to put the antiseptic method into use in French hospitals, to have the doctors admit the theory of germs which he had preached for so long with such force, and which Lister had now proved in actual practice.

Pasteur's method was simple in most cases. He stressed again and again the fact that surgical instruments should be passed through a flame to kill all

germs before the instruments were used on a patient. But this was too simple to impress "big" minds! Most of the surgeons could not see how this would prevent infection in the wound. They thought Pasteur an idiot. Anybody in his right mind could not believe such a simple precaution would prevent the dreaded infections that so often brought death. The surgeons had no idea what a good effect passing instruments through a flame could have. Pasteur tried to explain for them:

> I mean that surgical instruments should merely be passed through a flame, not really heated, and for this reason: if a sound [a surgical probing tool] were examined with a microscope, it would be seen that its surface presents grooves where dusts are gathered, which cannot be completely removed even by the most careful cleansing. Fire destroys those organic dusts entirely; in my laboratory, where I am surrounded by dusts of all kinds, I never make use of an instrument without having previously passed it through a flame.

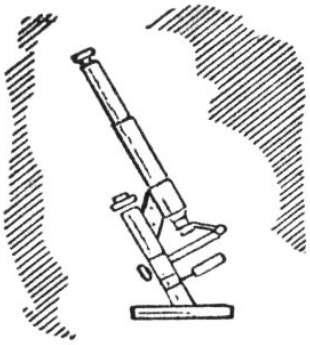
At each one of the sessions of the Academy at which Louis Pasteur spoke in favor of his germ theory, every time he tried to explain it further, he met with new difficulties, many of them stupid or jealous, but, nevertheless, hard to combat.

His attempts to introduce his methods into hospitals were the cause of many long and bitter arguments. Truly, this was one of the bitterest fights he had ever faced—a fight to the finish, the outcome of which meant so much to humanity. His speeches were fiery, for Pasteur was imbued with the spirit of a true crusader, which resulted in an eloquence the like of which had not been heard since the war. Several opponents dragged the old spontaneous-generation argument out of the closet to plague Pasteur further and take time from his new researches.

> What, then, is your idea of the progress of Science! [he wrathfully answered one of these objectors] Science advances one step, then another, and then draws back and thinks deeply before venturing upon a third. Because it is difficult to take the last step, does that mean that the first two steps were not successful? Do you say to a child who pauses before a third step, having already made two previous ones, "Thy former efforts are useless; never shalt thou walk?"

> Your object in wishing to overthrow what you call my theory is only to set up another in opposition; allow me to remind you by what signs all these theories are determined; the characteristics of false theories is their impossibility in anticipating new facts; whenever these arise, the old theories must be changed to conform with the new discoveries. True theories, on the other hand, express genuine facts and are characterized by their ability to foretell new facts, a normal consequence of those already established. Briefly, a true theory is always characterized by its fruitfulness.

But could these objectors ever be silenced? Could Pasteur ever gain enough ground to put his germ facts into practice for the good of mankind? He sometimes wondered. After all, he was fifty-two years old, hampered by a crippled hand and foot. Would he have the energy to win out, even though his faith never faltered?



The National Assembly of France gave Pasteur one piece of encouragement that was as highly important to his financial position as it was to his scientific career. The substantial reward of an annual grant of twelve thousand francs gave him funds with which to work and brought much-needed national attention to his work.

Paul Bert, the scientist who had charge of getting the plan accepted, told of Pasteur's accomplishments, summarized them to the authorities in this way:

> Pasteur's discoveries have revolutionized certain fields of industry, agriculture and pathology. One is filled with admiration when seeing so many important effects proceeding, by an unbroken chain of evidence, link by link, which leaves nothing to supposition. The famous saying "Genius consists of taking pains" was never better justified.
>
> It is this, together with the resulting accomplishments, that the Government proposes to honor by a national recompense. Your Commission unanimously approves the proposal.
>
> The recompense suggested is an award of twelve thousand francs a year, which is approximately the amount of the salary of the Sorbonne professorship, which M. Pasteur has resigned because of ill health. It is little enough when compared with the value of his services, and your Commission regrets that our

> financial state makes it impossible to increase the amount. But the Commission feels with its learned Chairman that the economic and hygienic consequences of M. Pasteur's discoveries will so develop that the French nation will later on desire to increase its testimony of gratitude toward him and toward Science which he so gloriously represents.

The plan was passed by a wide margin, six hundred and thirty-two votes against twenty-four.

Chappuis, now Rector of the Grenoble Academy, wrote to congratulate his famous friend. "Where is the Government which has secured such a majority?" And this majority was a rare compliment, since the Government seldom agreed so heartily on any issue.

Many of Pasteur's friends, Nisard among them, were convinced that now he should retire, live quietly with his family and make up for all his years of endless work. But Pasteur could see no advantage to such a life. His work was his excuse for living. If he could not press his experiments forward, he thought he might as well cease to live. He loved his family, loved being with them, but his work came first.

Even his physician insisted he must think of his health, give up his strenuous life of experiments and arguments. Mme. Pasteur found the solution to the problem by letting him work as hard as he wished during the day, then keeping him from all unnecessary social responsibilities, from any tasks aside from his work that could be avoided. They were never seen at balls or dinner parties. They did not even visit the theaters. After a day's labor, the scientist would walk slowly through the École Normale or rest in his home, pondering over his experiments until ten o'clock. Then, whether he slept well or not, he would be ready to start again at eight the next morning without fail.

In January of 1876, his home district asked Pasteur to run for a place in the Senate. He had no taste for politics but felt he must not shirk a patriotic responsibility. His son acted as his secretary for the campaign. Wishing the election only in order to have the opportunity of placing his accomplishments and the needs of French science before the Senate, he used the slogan "Science and Country."

The election, to the satisfaction of his family, who knew Pasteur should not be taxed with this extra burden of work, turned out unfavorably and he

lost. In fact his daughter, Marie Louise, wrote him a letter that arrived on the morning of election day, wishing him failure.

Another honor came that summer. Pasteur was elected as a delegate from France to an International Congress of Sericulture (silkworm cultivation) at Milan, Italy, along with Duclaux, Raulin and Maillot, who had been his assistants in his work during the French silkworm crisis.

These three helpers outlined the Pasteur method before the assembly to satisfy the intense interest of all those present.

During the congress, the delegates were taken on sightseeing trips around the neighborhood of Milan. The high point of these excursions for Pasteur was his visit to a seeding establishment named after him. He wrote the following letter to M. Dumas, his old master, who had first brought him into the study of the silkworm problem:

> MY DEAR MASTER:
>
> I am very sorry that you are not present: you would have been a partner to my satisfaction. My letter bears a Milan date, but in reality, the Congress being ended, we are guests at Signor Susani's country house for a few days. Here, from July 4, sixty or seventy women are busy for ten hours every day with microscopic examinations of the greatest accuracy. Never have I seen a better arranged establishment. Four hundred thousand moth cells are put under the microscope every day. The order and cleanliness are admirable; any possibility of error is eliminated by employing a second test following the first.
>
> I felt, in seeing my name in large letters on the façade of that splendid establishment, a joy which makes up for much of the foolish opposition I have experienced from some of my countrymen these last few years; it is spontaneous homage to my studies from the proprietors. Many silkworm raisers do their seeding themselves, by selection, or have it done by experienced workers. The harvest from that excellent seed depends on the climate only; in an ordinary season the production often reaches fifty or seventy kilograms per ounce of twenty-five kilograms.

Here Louis saw his work on silkworms put to use in a practical business establishment. He saw the proof of the accuracy and value of his weeks and weeks of laboratory study applied to a moneymaking industry.

At the end of the congress, Pasteur addressed the three hundred delegates and again stated his attitude toward science, toward its importance to the world and to mankind.

> Gentlemen [he said], I propose a toast—to the peaceful strife of Science. It is the first time I have the honor to attend an international congress on foreign soil; I ask myself what are the impressions produced in me, apart from these courteous debates, by the wonderful hospitality of the city of Milan, and I find two things deeply impressing me. First, that Science knows no nationality; and secondly, in seeming, but only in seeming, contradiction, that Science is the highest personification of nationality. Science knows no nationality because knowledge belongs to humanity, the torch that illuminates the world. Science should be the highest personification of nationality because that nation will always lead which shall be the first to advance by the efforts of thought and intelligence.
>
> Let us therefore strive in the peaceful field of Science for the supremacy of our several countries. Let us strive, for strife is effort, strife is life, when the goal is progress.
>
> You Italians, try to increase on the soil of your beautiful country the Tecchi, the Brioschi, the Tacchini, the Sella, the Cornalia. You, proud sons of Austria-Hungary, exemplify even more strongly than in the past the fruitful motive which a prominent statesman, now your representative at the Court of England, has left to Science and Agriculture. We who are gathered here remember that the first sericulture establishment was founded in Austria. And you, Japanese, may the cultivation of Science be one of your chief concerns in the amazing social and political transformation you are presenting to the world. We Frenchmen, bowed by the sorrow of our mutilated country, should show once again that great trials may give rise to great thoughts and actions. I drink to the peaceful strife of Science.

Pasteur had yet to forget the pain of the Prussian War, as his words showed. But his patriotism, his intense loyalty to France, glowed in his words to those representatives of other nations. “Bowed by the sorrow of our mutilated country,” he wanted this great gathering to know that France was making the best of her misfortunes and would be heard from in the world of Science.

Another conflict was on Pasteur's hands almost as soon as he returned to France. A young English physician named Dr. Bastian had raised the spontaneous-generation argument again, and Tyndall, an English physicist and great admirer of Pasteur, had gone about answering the doctor's statements. Finally Tyndall wrote Pasteur, telling him of the matter and reporting his progress:

> Putting into practice an idea which I thought of six years ago —the details of which are set out in an article in the *British Medical Journal* which I had the pleasure to send you—I reviewed most of the ground on which Dr. Bastian had taken up his stand, and I refuted, I think, many of the fallacies which had misled the public.
>
> The change which has taken place since then in the tone of the English medical journals is quite remarkable, and I am inclined to think that the general public has lost confidence in the accuracy of Dr. Bastian's experiments.
>
> In taking up these investigations, I have had the opportunity to review your labors; they have reawakened in me all the admiration I experienced when I first read about them. I intend to continue these investigations until I have put to flight all the uncertainties which may have arisen as to the indisputable accuracy of your conclusions.

Pasteur passed this letter on to the Academy for discussion but eliminated one paragraph as unnecessary to the problem. Leaving out this paragraph was typical of the modest but determined scientist who cared more for his work than for personal glory:

> For the first time in the history of Science [the paragraph read] we have, as regards epidemic diseases, the right to entertain the sure and certain hope that medicine will soon be delivered from quackery and placed on a real scientific basis. When that day arrives, Humanity, in my opinion, will know how to recognize that you should receive the largest share of her gratitude.

The discussion took much of Pasteur's time, but it did bring out one highly important fact that bore on his current work, that gave him a new proof of the necessity of passing surgical instruments through a flame before using them.

Working on Dr. Bastian's arguments, it was proved that heating a flask of liquid to a temperature of one hundred and twenty degrees centigrade will sterilize the liquid successfully but the liquid only. The flask had to be heated to one hundred and eighty degrees (far hotter than the boiling point of water) to kill all germs that might adhere to the sides of the flask as the steam passed out of the opening at the top. Likewise, passing an instrument through a flame was the easiest way of getting it over one hundred and eighty degrees and thereby killing all the germs.

Pasteur was particularly interested in solving once and for all the spontaneous-generation question because it was in direct opposition to his proved facts regarding germs causing disease and carrying disease from one person or animal to another.

He wrote Bastian to this effect in the midst of his own work of trying to convince the medical profession that human life could be saved from disease:

> Do you know why I desire so much to fight and conquer you? It is because you are one of the principal exponents of a medical theory which I think is fatal to progress in the art of healing—the theory of the spontaneity of all diseases. . . . That is an error which, I repeat over again, is preventing medical progress. . . . The future of the physician and surgeon depends upon the acceptance of the one or the other of these two doctrines.

And Pasteur worked on, hoping his doctrine could be made the accepted one, could bring health to the world.

In the midst of his struggles to defend his researches, to have them accepted and put to practical use by the Academy and the French people, Pasteur was drawn into one of his most bitter conflicts.

A disease known as “anthrax,” or “charbon” or “splenic fever,” had been destroying cattle and sheep, as well as a few human beings. In some districts in France, fifty out of every hundred sheep died of the disease. In one district of Russia, fifty-six thousand head of cattle died within the space of three years, from 1867 to 1870. Horses, oxen, cows, sheep, animals of every kind fell under the fever. Even five hundred and twenty-eight humans succumbed to the epidemic, being infected through slight wounds, like a pinprick or a tiny scratch, received while working with the animals, herding or butchering.

Delafond made some experiments on the disease back in 1838, while Davaine in 1850 began a serious study of the same menace. It was in 1863 when Davaine received a sample of the blood of a sheep that had died of anthrax from a farmer and studied it under the microscope. Davaine had read Pasteur’s study of butter ferment and wondered if the little cylindrical rods he saw in the sheep’s blood might perform an evil similar to that of the rods Pasteur described as causing the butter’s becoming rancid. Two other scientists attacked this theory with one of their own so that it was not until Dr. Koch, a young German physician, began seeking a means of cultivating these rods in 1876 that the charbon received important attention.

Dr. Koch’s work proved that the disease was caused both by the bacilli (or rods) and by spores (or tiny ovals present in the diseased blood when the

bacilli could not be seen). But his proof was not air-tight in the opinion of other scientists. Bert used one experiment as an added argument to the opposing theory that some added force caused the disease and that the bacilli and spores were merely a result or accompanying part of the solution. But no one knew what this added force was.

Consequently, in spite of Koch's researches, the cause of anthrax was still unknown.

Pasteur then broke into the argument and sowed an anthrax seed in a liquid that would make it grow. His microscope revealed not the short, broken rods of the bacilli but long, tangled networks that steadily grew longer and more involved. He set about proving that this form of bacillus or of spores was the cause of the disease and not some outside force.

He placed a drop of diseased blood in the liquid, then proceeded to extract one drop of the mixture and place it in a second flask. One drop of this weaker mixture was placed in a third container and the process continued until the single drop had been subdivided into forty solutions favorable for cultivating the germ of anthrax.

Since a drop from any of these forty mixtures produced death from anthrax in animals, Pasteur concluded that it was the germ, not some other substance that caused the disease.

A student of Pasteur, M. Chamberland, explained the results of the experiments in another fashion:

> By his admirable procedure, Pasteur shows that the rods which exist in the blood . . . are living beings capable of being reproduced indefinitely in favorable liquids, just as a plant multiplies by various cuttings. The disease germ does not reproduce itself only under the filamentous form, but also through spores or germs, like many plants which have two means of reproduction, by cuttings and by seeds.

So the real cause was explained. Both rods and spores caused anthrax. And these rods and spores could be multiplied again and again.

The medical profession immediately let loose a barrage of contradiction and criticism. Particularly a certain Colin, whose arguments were mere protests unsupported by evidence. Since the man was said to have made five hundred experiments on anthrax, he was taken seriously at the Academy until he faced Pasteur, who disproved his contentions.

But one old man of seventy-four years, a tall, sorrowful-looking doctor named Sedillot believed firmly in the work of Pasteur. In March, 1878, he read a paper before the Academy called *On the Influence of M. Pasteur's Work on Medicine and Surgery*. The document, after praising Pasteur's work and showing how, with that of Lister, it had improved the practice of medicine, closed with these glowing words:

> We shall have seen the conception and birth of a new surgery, a daughter of Science and of Art, which prove to be one of the greatest wonders of our century, and with which the names of Pasteur and Lister will always be gloriously connected.

This was also the paper in which the word *microbe* was first used to describe microscopic, disease-producing organism.

Sedillot's support and the persistent criticism of Colin brought Pasteur's work to the attention of the entire medical profession and its journals. Seeing these two widely separated views, the one violently in favor and the other violently opposed, turned a large portion of the doctors to a middle ground that accepted a good deal of Pasteur's proofs.

Pasteur's studies on germs came to a climax on April 20, 1878, when he made his famous address to the Academy of Medicine, outlining the principles he had discovered. This speech brought his accomplishments to a high point—and his conflicts with other scientists and with doctors to a crisis.

He began by tracing his studies from the beginning, from his first observation of tiny organisms up to the effect he had now decided they produced on animals and humans. He explained how each step formed the foundation for the next, from the fermentation studies up through the germ doctrine.

Reaching his solution of the problem of how disease was caused, how a healthy person or animal became ill or died, Pasteur said:

> This is proof that, in regard to certain diseases, we must certainly abandon the ideas of spontaneous poisoning or infection, of contagious and infectious elements produced suddenly within the bodies of men or of animals and causing diseases which are afterwards spread under identical shapes.

He then applied this conclusion to surgery:

> The water, the sponge . . . with which you treat or dress a wound, leave on its surface germs which, as you can see, are easily spread within the tissues, and which would unfailingly cause the death of the patient within a short time if the life in the limbs did not oppose the development of the germs! But how often is that resistance too weak! How often the patient's condition, his physical weakness, his moral condition, the unhealthy dressings, fail to arrest the activity of the Infinitesimally Small with which you have covered the wound! If I held the honored position of a surgeon, my being convinced of the dangers brought about by microbes spread over the surface of every object, particularly in the hospitals, would lead me not only to use thoroughly clean instruments, but, after carefully cleansing my hands and passing them quickly through a flame, I would only employ bandages and sponges which had formerly been heated to a temperature of one hundred and thirty to one hundred and fifty degrees centigrade; I would only use water that had been raised to a temperature of one hundred and ten to one hundred and twenty degrees centigrade. All these are easy practices, and even then I should still have to fear the germs contained in the atmosphere surrounding the bed of the patient; but observation teaches us every day that these germs are almost insignificant in number compared to those which are found on the surface of objects or in ordinary clear water.

Having once stated these facts, Pasteur immediately went to work to carry his results further. Much needless time was still spent in trying to answer his enemies' protests.

About this time another epidemic of anthrax was mowing down French cattle by the herds. Pasteur was sent by the Minister of Agriculture to Chartres, where the disease had struck down the cattle in earlier epidemics and was now doing tragic damage. No explanation could be found for the new outbreak of the disease.

Chamberland, Vinsot and Roux joined Pasteur in the mission, and soon the famed scientist was limping slowly through the fields, observing everything with a skilled eye.

On one man's property, Pasteur noted that the soil in one part of his land was of a different color than the rest and was told by the owner that this spot was the burial ground for sheep that had died of anthrax.

Studying the surface of the ground closely, Pasteur saw earthworms coming to the surface, throwing up tiny particles of the dirt below the surface. Immediately he had the idea that this soil might contain germs from the animals buried there. Testing it proved he was right. The germs secured from the bits of soil produced rapid death when used on guinea pigs. The scientist at once recommended:

> One should be careful not to bury animals in fields intended for growing hay or pasturing sheep. Whenever possible, burial grounds should be chosen on sandy or chalky soil, not fertile, easily dried, and unfavorable to the life of earthworms.

The studies at Chartres continued for several years. Chamberland and Roux would move there from the laboratory in the Rue d'Ulm at the end of July, with Pasteur coming down about once a week to go over their results and plan new lines of study.

Each morning Roux and Chamberland would go out to the sheep fields and check on the animals, then move to a knacker's yard, where old or dead horses were kept, for autopsies on dead animals. In the afternoons, they wrote up their results, drew up reports to be sent to Pasteur, and laid out the next day's tasks.

On the days when Pasteur visited them, the three would hurry over their dinner at the Hôtel de France and then press their horses for more speed as they drove to St. Germain, where a M. Manoury had placed his flocks and farm at their disposal. But in spite of the jouncing of the hurrying carriage, the three talked of nothing on these drives but anthrax—what they had done during the past week, what they wanted to do next week.

Pasteur would listen quietly, putting in a word here and there, then rush from the hack when they reached the farm, only to take up his stand by one of the sheep hurdles and gaze mutely for hours as the animals passed by. No detail was too small to escape the scientist's attention. The faintest of clues told him a definite series of facts. To every remark of the shepherds he listened raptly, explaining later to his colleagues that the opinions of these lonely herders were always worth analyzing.

These afternoons seemed all too short. Pasteur seemed just to be started when the towers of the Chartres Cathedral faded into the dusk and his helpers prevailed upon him to plod slowly back to the carriage.

Into these happy, work-filled weeks broke another attack by Pasteur's old enemy, Colin, whose earlier barrage had been the basis of Colin's claim

that he had seen serious cases of anthrax where no anthrax germs were present. Pasteur saw through Colin's opposition because Colin never brought evidence to back up his contentions, only sat in his chair and fired contradictions at his opponent. In their first set-to, Pasteur plotted a ruse that he hoped would silence the objector permanently. He made a public statement that birds, especially hens, were for some reason immune to the anthrax. Colin immediately came back with a contradiction.

Seeing his plan was working, Pasteur asked to see a specimen hen infected with charbon—then repeated his request at the next meeting of the Academy. At last the vacation period came with no diseased hen forthcoming. Resuming work, Colin promised to produce the hen—then at last had to retract his contradiction.

So far, so good, Pasteur smiled to himself and forthwith announced to Colin that a hen could be infected and that he, Pasteur, would go about proving it. All the time he had known that the body temperature of fowl is higher than that of animals and that this higher temperature protected the hen against the anthrax germ.

It was a simple matter to dip the hen in water, lower her temperature about five degrees and then inject the anthrax infection. Promptly, the hen died.

To strengthen his proof, Pasteur made the same steps with another hen but warmed her with a towel as soon as signs of the disease began to appear. Her higher temperature repelled the disease and she recovered.

Announcing this procedure, Pasteur believed he had silenced Colin. The fiery contradictor's lack of an answer made his next attack, springing up in the midst of the Chartres experiments, doubly discouraging. Worse, Colin accused Pasteur of dishonesty in his earlier work with the two hens.

At the next meeting of the Academy, Pasteur assigned himself a task that would satisfy Colin's charges and demands. If Colin wanted to hold in his hands a hen that had been infected with anthrax, he, Louis Pasteur, would place such a hen in those hands. The microscopic examination of the fowl would be made by Colin in the presence of the Academy and his discoveries written down and signed by witnesses, to be used as evidence against further attacks. Pasteur finished his statement on his customary note of sincerity:

"In these arduous investigations, whilst firmly condemning frivolous opposition, I feel nothing but respect and gratitude toward those who will point out to me any possible error I may make."

Colin and three other members served as the witnesses when Louis came into the Academy carrying three hens that, by the method of cooling in water and injecting with germs, were suffering with anthrax. Boastfully, swaggeringly, Colin dissected the first hen—then instructed the gentlemen to join him in signing the report. He did not inspect the second and third hens. The presence of anthrax germs in every portion of the first fowl had knocked his arguments and insulting charges into a cocked hat.

Working on human diseases, as well as those of animals, made it necessary for Pasteur to make regular visits to hospitals and even to operating rooms. Few experiences could have caused him more discomfort, for he became violently ill from watching surgical work of any kind. Again and again he would be forced to go home to recover. But he would always be back again the next day. The health of the world was his responsibility. His own weakness, he felt, should not stand in the way of work far more important than his own life.

But these visits, unselfish and well-meaning as they were, soon brought Louis Pasteur to a conflict in which he was afraid he might be defeated, to a conflict so bitter that he was forced to withdraw from Paris.

Chapter XIV Vaccination!

In his tours of the hospitals and his studies of human sickness, Louis Pasteur saw with the Paris doctors the dread effect of the disease that was taking the life of almost one out of every four mothers lying in at the hospitals in the maternity departments.

It was a grave danger for a woman to become a mother, just as it was to face any kind of an operation in a hospital. All of the French medical profession was seeking some cure for the epidemic of this puerperal fever, which was causing the deaths of so many mothers with young babies.

At the Academy of Medicine, Pasteur was listening to a speech on the disease by another member. The whole gathering was following raptly the words of the speaker, his explanations of the causes of the disease.

But Louis Pasteur could not stand it any longer. Excited, he sprang to his feet:

"Neither of those things is responsible for the epidemic," he shouted. "It is the nursing and medical staff who carry the microbe from an infected patient to a healthy one."

Accustomed to Pasteur's violent interruptions, the speaker went on, declaring there could be no such microbe. He was forced to pause again, for Pasteur had rushed from his desk, snatched a piece of chalk and was now scribbling on the blackboard.

"There, that is what it looks like," he told the amazed audience.

On the board was a chainlike design, a drawing of the germ causing childbed or puerperal fever. But, as always, Pasteur received little approval.

Only a few students would accept his theory of this germ. Pasteur could only keep hammering away at hospital authorities and doctors, knowing countless human lives were involved in the success or failure of his work. “I will force them to see,” he insisted. “They must see.”

His critics may have been right in stating that his manner was too insistent, that he would have nothing but the perfect handling of these cases in the hospital. But Pasteur knew what he was doing and saw the wide importance of his methods. Perhaps, he was looking into a future where, as today, a case of puerperal fever is a disgrace to any hospital, a sign of careless and unsanitary treatment of the patients.

Louis Pasteur was forever seeking some kind of a remedy, some kind of protection against diseases of men and animals. Now that he knew the germ that caused anthrax or charbon, that swept whole flocks and herds into death, he drove himself unmercifully to find some method of combating this germ.

At this same time, chicken cholera was striking the same wholesale death upon broods of fowls as was anthrax on cattle and sheep. Pasteur looked into this plague and also discovered its germ.

This microbe he cultivated in a liquid, just as he did that of anthrax. He proved, as in the case of anthrax, that liquids made from the germ, held equally dangerous quantities of the disease-producing virus. He treated a number of healthy hens with the various solutions and found every one of them died. The first step was accomplished.

Summertime of 1879 came on, and Pasteur was wheedled into taking a vacation, his assistants being allowed to close the laboratory for several weeks.

When he returned to his flasks, Louis Pasteur was greatly disappointed to discover that none of the liquids in them would produce chicken cholera in hens. The liquids seemed to have lost their strength, become sterile. He was ready to throw them away when an idea flashed across his mind. He did not know that he was near one of the greatest discoveries in the whole history of medicine, in the whole history of science! He had no idea what results his inspiration would bring. But something told him he should find what effect a new, full-strength solution would have on the hens on which the weakened solution had produced no visible effects.

Quickly he made a new solution, tested it on entirely different hens and found that it brought about their almost immediate death from cholera.

Now he injected this new, strong solution into each hen that had already been treated with the old, weak mixture. Then he watched them carefully. They showed no signs of cholera! The first injection of the weak solution had protected them against the sickness and death ordinarily produced by the strong solution! Louis Pasteur had produced a vaccine against chicken cholera!

Always thorough, he set out to find the exact method of preparing the vaccine solution. Much careful experiment through the fall of 1879 and spring of 1880 told him that placing the strong liquid in a tube plugged with cotton in such a way that air at a temperature of thirty-seven degrees centigrade could pass through would weaken the mixture properly after a given number of hours.

Now the problem was to discover a vaccine or fluid that would have the same effect on anthrax, that would protect animals against the plague. And, as soon as possible, vaccines that would protect humans against various diseases.

Pasteur came back to Paris in September to fight for the vaccine idea in the Academy of Medicine where he had faced so many rebukes in the past. He brought into his discussion the possibility of vaccination against smallpox.

Jules Guerin, an eighty-year-old veteran of medicine, but still full of fight, who could not endure witnessing the beliefs he had held all his life smashed to bits by Pasteur's discoveries, loudly interrupted the latter's explanations in regard to human vaccines, by declaring with absolute prejudice:

"Human vaccine is nothing but the product of cowpox and horsepox with which man is inoculated and which becomes humanized by its successive transmissions into man."

But our Knight of the Laboratory, sure of his ground, set Guerin back on his heels: "To pretend to explain the connection between smallpox and human vaccine by speaking of only vaccine and its connections with cowpox and horsepox, without even mentioning the word smallpox, is sheer ambiguity, done purposely to avoid the real issue of the discussion."

Becoming excited by Guerin's continued antagonism, Pasteur let go with a flow of facts and sarcasm which were culminated by ridiculing certain experiments his opponent had conducted, and which were so effective and so accurate that the members burst into laughter.

This was too much for Guerin. With a roar he rushed at Pasteur but was stopped by a fellow member before he could reach him. The meeting broke up in a general uproar.

The next day Guerin sent two seconds to call upon Pasteur and demand a duel.

At the advice of the Permanent and Annual Secretaries of the Academy, Pasteur wrote a letter of apology to the Chairman of the Academy, stating that he had meant no personal offense but only wanted to give his proven results every opportunity to show their worth.

The *Journal of Medicine and Chemistry* commented on his sincere view in these words:

> We admire Pasteur for his humility, who is so often said to be combative, and always disposed to quarrel. He comes before us as a scientist who every now and then makes brief, satisfactory and highly interesting communications. He is not a medical man, but has been led solely by his genius to the opening of new ways in the most difficult studies of medical science. Instead of the attention and admiration he deserves, he meets with a ferocious opposition from some quarrelsome individuals, who always contradict after having listened as little as possible. If he makes use of a scientific expression which is not generally understood, or if he uses a medical expression which is not quite correct, he is faced with the specter of endless discussions, intended to prove that everything was well with medical science before it was aided by the valuable studies and resources of chemical experimentation.

Meanwhile Pasteur was having difficulty with the anthrax vaccine. The chicken cholera microbe lost its strength with age but the anthrax rods produced equally deadly and strong spores or ovals as they aged, so that some other method of preparing the vaccine had to be discovered. If it were possible to prevent this strong reproduction of spores, he would have the answer.

Following were days and weeks of nervous tension, great anxiety for the Pasteur household, now enlarged by the addition of a son-in-law and a daughter-in-law. Louis Pasteur had to be watched. His health would not permit him to overdo. And this constant strain, this endless trial and error of looking for that vaccine was telling on him.

But perseverance has its reward! Finally Pasteur discovered that the anthrax solutions were unable to produce spores if kept at a temperature of forty-two to forty-three degrees centigrade when exposed to the air for a certain number of days. At last he had won out!

Of course, as soon as the news was released, new controversy broke out. This time from M. Rossignol, who had written about Pasteur earlier in the *Veterinary Press*.

> Will you have some microbe? It is everywhere present. Microbiolatry is the fashion, it reigns undisputed; it is a doctrine which defies discussion, especially when its Pontiff, the learned M. Pasteur, has pronounced the sacramental words, "I have spoken." Alone the microbe is and shall be the characteristic of a disease; that is understood and taken for granted; from now on the germ theory shall be exalted above pure clinics; for only the Microbe is true, and Pasteur is its prophet.

Biting words these!

Now Rossignol wanted to put Pasteur in a position where he would have to prove dramatically the truth of his doctrine of anthrax vaccine or fall ignominiously before his critics. Rossignol proceeded to collect funds for a huge public demonstration that would make or break Pasteur's reputation—and Rossignol seemed to hope it would do the latter. The vaccine had had no real tests outside the laboratory, so accepting this challenge might be a dangerous chance for Louis Pasteur to take.

The proposition was put up to the Agricultural Society of Melun, whose chairman issued the challenge to Pasteur. He was to submit his vaccinations to a public investigation in Melun, Fontainebleau and Provins. Pasteur accepted without hesitation.

Before the month of April was over, in the year 1881, the program for the demonstration was drawn up by Pasteur. His opponents left him no loophole, no chance for the slightest error. He would stand or fall on the results. His friends and his assistants were thoroughly worried about the whole affair.

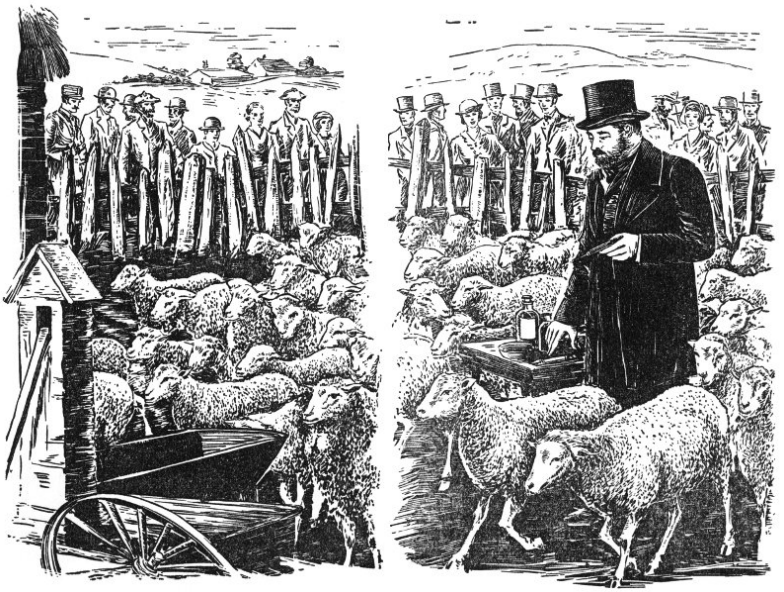
One of his friends remarked, "You remember what Marshal Sainte-Cyr said of Napoleon, that 'he liked hazardous games with a touch of grandeur and audacity'? It was neck or nothing with him, and you are bound for the same course."

Pasteur was not at all disturbed by such nervousness. “What was successful in the laboratory on fourteen sheep,” he explained to his staff, “will be just as well at Melun on fifty.”

Sixty sheep were put at M. Pasteur’s disposal by the Melun Agricultural Society. Twenty-five were to be vaccinated with Pasteur’s new solution once, then again, twelve to fifteen days later. Two weeks after the second shot, the first twenty-five with twenty-five additional sheep, were to receive injections of a solution of anthrax germs strong enough to cause the disease. The remaining ten sheep were to be left untreated, as a basis of comparison with the fifty treated ones.

M. de la Rochette offered ten cows for the same test, six to be vaccinated and four not to be. Pasteur stated he could not guarantee positive results, as his charbon vaccine for cows had not been brought to the perfected stage of the sheep solution, but he thought the fluid would prove successful.

It was a strange assortment of human beings that swarmed the farmyard at Pouilly le Fort on May 5 to see the first injection made. Articles in the medical journals and Paris newspapers had brought great doctors, men of science, members of the Government who strolled insolently over the rough ground, delicate nostrils pinched with displeasure at surroundings that were no cleaner than those of any other barnyard. Still, many of these men would have risked far greater discomfort for such an opportunity to scoff at this little scientist so sure of his cure for anthrax.



It was a strange assortment of human beings that swarmed the farmyard at Pouilly le Fort to see the first injection.

Crowding the affluent gentlemen of the city were reporters and middle-class men—especially veterinaries—all looking shabby next to the finery of the rich, despite the fact that they, too, had come to scoff. A serum that would prevent charbon would be a great thing for press and veterinaries alike, something to hope for in the future, perhaps. Meanwhile, they could jeer Pasteur. Jeering wouldn't prevent their applauding him if he did achieve the impossible and produce a workable preventative.

Out of place among the doubters and the scathers, roughly clad, honest farmers and sheepherders who had helped Pasteur with his tests watched with awe the other visitors. They could not understand why these queer people could wish to insult such a kind and sincere man as M. Pasteur.

Then such thoughts passed from their minds as they pressed shoulder to shoulder with the scoffers to see the scientist signal for the first animal.

The sheep to be vaccinated were divided from the rest of the flock under the large shed. At the last minute two goats were put into the group to be vaccinated, replacing two of the sheep.

Then the twenty-five were lined up and passed, one by one, before Pasteur and his aides, who injected five drops of the vaccine under the skin of the sheep's right thigh.

Five cows and one ox took the places of the original six cows and were treated behind the shoulder. The sheep vaccinated were given a distinguishing mark on their ears, the cows and ox on their right horns.

For the next twelve days, the assistants checked on the twenty-five treated sheep and found not even an abnormal rise in temperature. On May 17, a second vaccination was made with a solution strong enough to kill many of the sheep had it been used for the first dose.

The experiment on his mind, Pasteur wrote the following to his son-in-law:

> On Tuesday, May 31, the third and last injection will take place—this time with fifty sheep and ten cows. I feel very confident, for the two first, on the 5 and 17, have the very best results without any mortality among the twenty-five vaccinated subjects. On June 5, at the latest, the final result will be known. There should be twenty-five survivors out of twenty-five vaccinated, and six cows. If we are completely successful, this will be one of the finest examples of applied science in this century, consecrating one of the greatest and most fruitful discoveries.

On May 31, another large crowd gathered to watch Pasteur administer the final injection. All fifty sheep were given a dose of disease-producing fluid three times as strong as prescribed in the original agreement. Pasteur shook the bottle vigorously before each shot to satisfy another complainer.

After setting the next meeting for June 2, the visitors retired, some of one mind about the experiment, some of another. A few had even drunk to Pasteur's failure that morning.

The eve of June 2 was a nightmare to the great scientist. He had proclaimed he would show results that would be a boon to the nation, to agriculture, to medicine the world over. Could he carry out that promise?

Chapter XV The Crucial Test—

At two o'clock on the afternoon of June 2, Louis Pasteur arrived at the farm.

The little barnyard, alive with people at the earlier meetings, now seemed a solid mass of human beings, humans that rushed in a pack to Pasteur's side as he started his hesitant march toward the pen that held the sheep.

Far different was the attitude of that mob as they plowed along at his heels. The gentlemen of the city bowed deferentially. The scoffing had ceased. Every man's eyes were on the slowly advancing Pasteur.

Though he had had an inkling of the results of the test, the tension of the night before, of making himself wait until just two o'clock to arrive, the excited hum darting through the crowd—all set his pulses wrenching into their beats.

Breathlessly quiet, the press around the walls of the pen followed Pasteur's inspection of the ear tags on each of the twenty-two sheep lying on the ground, of the three ailing ones braced helplessly against the fence. Eagerly they watched his lips as he muttered, "These twenty-five have not been vaccinated. Twenty-two are dead, three more are dying of anthrax."

Now the pent-up enthusiasm could hardly be contained as Pasteur checked the remaining twenty-five animals, then slowly walked to the opening in the fence.

Only a nod of the head told the story. Pasteur had almost escaped before the tumultuous cry burst out. "Bravo! A success! The vaccinated animals

remain healthy and unaffected by anthrax!"

The experiment was a complete success! Again Pasteur had made history.

The last unvaccinated sheep died on June 4, completing the test. So Pasteur wrote to his daughter:

> Success is definitely confirmed; the vaccinated animals are keeping perfectly well, the test is complete. On Wednesday, a report of the facts and results will be drawn up which I shall communicate to the Academy of Sciences on Monday and on Tuesday to the Academy of Medicine.

The veterinary surgeons who had been Louis Pasteur's most severe opponents on the study of anthrax now came over to his side, completely convinced by the experiment at the farm. Thousands of sheep were vaccinated in the following months by the Pasteur method.

A letter to Pasteur, written from Lyons on June 5 by Bouley, General Inspector of Veterinary Schools, gives one example of the enthusiasm with which these doctors praised the man whose scientific life had begun with the study of crystals:

> *Dearest Master*:
>
> Your triumph has filled me with joy. Now that the days are long past since my faith in you was somewhat wavering, not having fully realized your spirit, as long as the event—which has just been completed in a manner so strictly in conformity with your predictions—was still in the future, I could not keep myself from feeling anxious, and you yourself were the cause, since I had observed that you also were a prey to it, like all inventors on the day which reveals their glory. At last your telegram, for which I was pining, came to inform me that the world has found you faithful to all your promises, and that you have inscribed one more great date in the annals of Science, and particularly in those of medicine, for which you have opened a new era.
>
> I feel I cannot express my great joy at your triumph; first of all, for you, who are today receiving the reward of your noble efforts in the pursuit of Truth; and—shall I tell you?—for myself, too, for I have so intimately associated myself with your work that I should have felt your failure just as if it had been my very own.

> All my teaching at the Museum consists in relating your labors and predicting their fruitfulness.

These were days of triumph for Louis Pasteur. He seemed at last to be receiving the acclamation he had so long deserved. Many who had heard of him as an almost despotic, intolerant, irritable man saw him for the first time, heard him lecture and discovered him to be far different. Those who heard him at lectures saw the real Pasteur, the quiet, modest, hard-working man who was always willing to listen to honest opposition, to defend his proven facts and offer them to anyone who could use them profitably or for the advancement of Science.

Desiring to acknowledge Pasteur's great accomplishment, the Government wished to award him the Grand Cordon of the Legion of Honor, the order of which he was already a member.

Pasteur was grateful for this grand compliment, especially for the national recognition of his work. But he made one condition to the authorities. He would accept the decoration if his two assistants, Chamberland and Roux, would be awarded the red ribbon of the Legion. He told his son-in-law of his wishes in a letter, written late in June.

> What I desire most in my heart [he wrote] is to have the Cross awarded to Chamberland and Roux. Only if that happens will I accept the Grand Cross. They are making many sacrifices! Yesterday they went to a farm fifteen kilometers from Senlis, to vaccinate ten cows and two hundred sheep at Vincennes. On Sunday they were near Coulommiers. On Friday we are going to Pithiviers. What I desire chiefly is that the discovery [of the vaccine] should be marked by an exceptional distinction to two devoted young men, full of merit and courage. I wrote yesterday to Paul Bert, requesting him to intervene most warmly in their behalf.

While Louis Pasteur was busy vaccinating more herds and making these unselfish efforts for his collaborators, his opponents were again working against him. This opposition was just starting when a faithful friend strode into Louis Pasteur's laboratory, his face beaming with a wide smile. Mme. Pasteur described the cause of the man's joy in a letter.

> M. Grandeau, one of Pasteur's assistants, has just brought the news to the laboratory that Roux and Chamberland have been

awarded the Cross and M. Pasteur the Grand Cross of the Legion of Honor. Hearty congratulations were exchanged in the midst of rabbits and guinea pigs.

Soon the opposition to the great experiment with the sheep and cows at Pouilly le Fort crystallized into a definite campaign. Pasteur's opponents asserted that the fluid with which he had infected the animals with anthrax was only an artificial laboratory preparation, would not cause death in sheep as soon or as effectively as actual blood from a diseased animal. Some even said Pasteur had prepared this liquid in a way that would show his vaccine favorably, paying no attention to whether or not it really represented the virus which caused anthrax.

To prove their contention, the adversaries were conducting an experiment at Chartres. Sixteen unvaccinated sheep were put with a lot of nineteen vaccinated sheep from Alfort. On July 16, the thirty-five sheep were brought together.

A sheep which had been dead for four hours from anthrax was brought from a neighboring farm and tested. The test of its blood and inspection of the body proved the animal had died of anthrax.

Ten drops of this sheep's blood, which obviously was infected with the disease, were placed in each of the thirty-five sheep, alternating the injections between the vaccinated and unvaccinated ones.

On July 18, two days later, ten unvaccinated sheep had already died and most of the others had fallen sick. The vaccinated ones remained perfectly well.

While the ten dead sheep were being examined, two more passed away with three more on the next day.

As General Inspector of Veterinary Schools, Bouley, who had written Pasteur such a glowing letter after the Pouilly le Fort demonstration, was informed of the results of the Chartres test by Boutet, another veterinary. Bouley wrote Louis Pasteur immediately of the outcome:

MY DEAR MASTER:

Boutet has just informed me of what happened at Chartres. All has been accomplished according to the master's words; your vaccinated sheep are triumphant and all the others, with one exception, are dead. That result is especially important in a countryside where unbelief was so much in evidence in spite of all

> the demonstrations made. It seems that the doctors especially were doubtful. They said it was too good to be true, and they counted on the strength of the natural charbon [anthrax] to find your method at fault. Now they are converted, Boutet writes, and the veterinary surgeon, too—one among others, whose mind, it seems, was positively stubborn—also the farmers. There is a general Hosannah in your honor.

After congratulating Pasteur on the Grand Cross, Bouley went on to mention Roux and Chamberland:

> I was also very pleased to hear of the distinction you obtained for your two young collaborators, so full of your spirit, so devoted to your work and your person, and whose assistance is so self-sacrificing and disinterested. The Government has honored itself by so happily bestowing a distinction which amplifies the greatness of your discovery in which they had a part.

Another reward, one whose acceptance gave Pasteur another opportunity to further the glory of his beloved France, came soon after the Chartres experiment. He was invited to represent France at the International Medical Congress in London.

Coming into St. James Hall, London, quietly with his son and son-in-law, Louis Pasteur was recognized by one of the stewards and conducted to a place on the platform among the notables of the assembly.

As he approached the stand, applause thundered through the overflowing audience of delegates. Pasteur turned uncomfortably to his companions, whispered, “It is no doubt the Prince of Wales arriving; I ought to have come sooner.”

“But it is you that they are all cheering,” Sir James Paget, President of the Congress, told him, with a friendly smile.

Pasteur modestly took his seat, still surprised with it all. It was hard to believe. Delegates from great nations cheering him, cheering Louis Pasteur who had had to return to the tanner’s yard at Arbois because he was too homesick to stay in Paris. Could it all be true!

Another baffling surprise came a few minutes later when the Prince of Wales with his brother-in-law, the German Crown Prince, entered. “Almost a dream,” Pasteur thought, “he, Louis Pasteur, receiving acclamation equal to that of royal princes.”

His reception was a joy, too, because of the fact that he represented France. Praising him was praising his native country. Many German scientists were there and would be able to see how France had made great forward strides in Science in spite of the Franco-Prussian War!

Pasteur speaks of his triumph and one coming later in the day in a letter written to his wife:

> I felt very proud [he wrote], I felt inwardly very proud, not for myself—you know how little I care for triumph!—but for my country, in seeing that I was especially singled out among that huge gathering of foreigners, especially the Germans, who are here in greater numbers than the French, whose total, however, reaches two hundred and fifty.
>
> After the meeting, we lunched at Sir James Paget's house; he had the Prussian Crown Prince on his right and the Prince of Wales on his left. Then there was a gathering of about twenty-five or thirty guests in the drawing room. Sir James presented me to the Prince of Wales, to whom I bowed, saying that I was happy to salute a friend of France. "Yes," he answered, "a great friend." Sir James Paget had the courtesy not to ask me to be introduced to the Prince of Prussia; though one should, of course, have room for nothing but good taste under such circumstances, I could not, however, appear to wish to be presented to him. But he himself came up to me and said, "M. Pasteur, allow me to introduce myself to you, and to tell you that I had great pleasure in applauding you just now," adding some more pleasant things.

During the meeting, Paget asked that M. Pasteur lecture on his vaccines for chicken cholera and anthrax. In the address, Pasteur proceeded to explain how he had prepared the vaccine and in what way it was to be used.

In closing, he described the results the new method had obtained:

> In a fortnight, we vaccinated, in the Departments surrounding Paris, nearly twenty thousand sheep, and a great many oxen and horses. . . .
>
> I do not wish to conclude, however, without relating to you the immense joy that I feel in thinking that it is as a member of the International Medical Congress sitting in London that I have made known to you the vaccination of a disease more terrible for

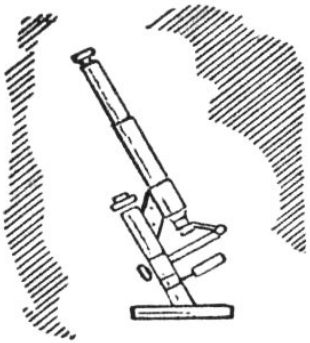
> domestic animals than is smallpox for man. I have given the word vaccination a meaning which I hope Science will consecrate as a homage to the merit and immense services rendered by your Jenner, one of England's greatest men. It makes me extremely happy to glorify that immortal name on the very soil of the noble and hospitable city of London!

Dr. Daremburg, a correspondent at the meeting for a French journal, rejoiced also at the wild enthusiasm with which Pasteur was entertained at the congress.

> Pasteur was the greatest success of the Congress [Dr. Daremburg wrote]. When M. Pasteur spoke, when his name was mentioned, a thunder of applause rose from all benches, from all nations. An indefatigable worker, a sagacious seeker, a precise and brilliant experimentalist, an implacable logician, and an enthusiastic apostle, he has produced an invincible effect on every mind.

But Pasteur did not return to Paris to rest on his laurels. Already a problem, a new scientific crisis was occupying his attention. Disease was cutting down men in wide swaths. Could the principle of anthrax vaccine be applied to human beings? Pasteur could not rest until he could answer that question.

Chapter XVI A Vacancy in the French Academy



The date set for election to the French Academy in the year 1882 was December 8. When Louis Pasteur was urged to present himself as a candidate he was for a moment overwhelmed. All his life he had spent in centering his attention on his passionate love for the study of science and now that honor was coming to him for his great work in the field of science and medicine, he was at first embarrassed by the attention shown him.

It was a very great honor to become a member of the French Academy. Many would-be candidates went at securing a membership in the Academy much in the way that a political office seeker would go about booming himself for a political job. Certain candidates spent a good share of their time months before the election came up in paying calls on influential people, flattering the voters and furthering their candidacies in every respect.

To a friend who approached Pasteur, he remarked: “I have never in my life contemplated the great honor of entering the French Academy. People have been kind enough to say to me, ‘Stand and you will be elected.’ It is impossible to resist an invitation so glorious for Science and so flattering to myself.”

And many members of the French Academy thought the same. When Alexandre Dumas learned that Pasteur was considering becoming a member of the Academy he refused to let Pasteur call on him. He said:

“I will not allow him to come and see me. I will myself go and thank him for consenting to become one of us.”

Thus it came about that instead of soliciting those in the Academy, Pasteur was himself solicited by them, an unprecedented reversal of the usual procedure. His election, a unanimous one, took place, a letter was sent him informing him of the result and soon our Knight of the Laboratory entered the French Academy, filling the place of Littré, the great scientist and philosopher.

A reception at the French Academy is like a first night at a theater; a special public is interested days before in every coming detail. The whole literary and scientific world has its celebration.

Pasteur, as a new member, was expected to give a speech and in competition with some of the greatest orators of the time he felt more or less out of his element. After all, there is a great difference between studying diseases and vaccines in the quiet of the laboratory and standing before an imposing group of the greatest minds and personages of a nation delivering a speech which would at once be simple and effective.

But Pasteur was not afraid. Neither was he overconfident. The span of years which had seen him battling the elements of disease had made him realize a great truth, that lacking the time to read and study literature to any great extent, he should content his mind only with the best. So whenever he found time to do any reading, he read only the worthwhile and the best.

His speech consequently was a masterpiece of modesty and humbleness.

"I would feel some confusion in presenting myself before this illustrious assembly," he said in the beginning, "but I realize that the praise is not rendered to me but to the great cause of Science."

Then he continued by giving praise to Littré, whose place he was taking. Now Littré was a positivist, that is, one who followed a philosophy which denies that we can know anything but the natural phenomena or properties of things—that is, the world should affirm nothing, deny nothing beyond what can be easily seen or proven. Therefore it denied God as the First Cause of all things. Pasteur praised Littré's personal and mental attributes, but proclaimed that Littré was wrong in his philosophy.

> What is beyond? [he proclaimed]. The human mind will never cease to ask that question. It is no use to try to answer. Beyond is infinite space, infinite time, infinite grandeur. He who proclaims the existence of the Infinite—and who can help it?—declares by that statement more of the supernatural than can be found in all the miracles of religion; for the idea of the Infinite has a double

> significance, namely, it forces itself upon us and yet we cannot thoroughly understand it. When this idea comes to us we can but kneel. . . . Everywhere I see an expression of the Infinite and because of that in every heart there is something of the supernatural.

Then Louis Pasteur continued with the words that will ever live, words that seem to have been an inspiration from above.

> Blessed is he who carries within himself a God, an ideal, and who obeys it; ideal of art, ideal of science, ideal of the Gospel virtues, therein lie the springs of great thoughts and great actions, they all reflect light from the Infinite.

The week that followed Pasteur's introduction as a member of the famous French Academy brought him considerable attention from outlying towns and provinces.

The town of Aubenas was erecting a statue to Olivier de Serres, who founded the silk industry in France in the sixteenth century. Now the citizens of Aubenas wished to associate with Olivier de Serres the name of Louis Pasteur as the man who had preserved the silk industry for all people and for France.

A few months before this the Melun Agricultural Society had held a special meeting in Pasteur's honor and had decided to strike a medal with the face of Pasteur on it in commemoration of one of the greatest services ever rendered by Science to agriculture.

But now that the excitement was over, Pasteur, first and last a scientist, was beginning to tire of the praises heaped upon him. Almost immediately he began experiments on a disease prevailing among horned cattle known as peripneumonia.

The great veterinary surgeon, Rossignol, had been making a study of the deaths caused by the inoculation with a certain virus used in checking the disease among cattle.

Pasteur, with his helpers, went to work. For some time they tried vainly to cultivate the virus of peripneumonia in chicken broth, veal broth, yeast water and other agents. Louis gathered the virus from the lung of a cow which had died of peripneumonia by means of sterilized tubes. The virus thus obtained was kept sterilized and injected under the skin of the tail of other animals.

Again success crowned his efforts!

In 1882 Pasteur published in a medical paper the conclusions he had drawn from his experiments.

> Pure virus remains virulent for weeks and months. One lung is sufficient to provide large quantities of it, and its purity can easily be tested in a stove and even in ordinary temperature. From one lung only, enough can be secured to be used for many animals.

But public acclaim would not leave Pasteur alone. The town of Aubenas called him there for a celebration. And what a celebration! Pasteur felt somehow confused and perhaps a little embarrassed. To so unassuming a person this could not be otherwise. Visualize him sitting in the open carriage on his triumphant march through the small city, his eyes turning to the right and left to express what his tongue could not. And as he was conveyed under the great floral arches and along a roadway, strewn with flowers, and heard the music of the bands and the singing and cheering of the crowds, follow him in imagination. But not as a man of maturity and deep understanding, rather as a boy, incredulous and amazed at the great tribute paid him.

When the celebration had partially settled down, there were speeches of praise by the mayor, the Municipal Council and the Chamber of Commerce. At their conclusion, Pasteur was presented with a medal, a work of art with his own face reproduced in metal. On the medal there was also depicted a microscope, that microscope which not long before had been declared an impractical instrument.

While presenting the medal to Pasteur, the speaker said: “You have been the kindly magician whose intervention conjured away the scourge which threatens us. We hail you as our benefactor.”

And Pasteur, in characteristic fashion, accepted the tribute as an offering to science. “Science has been the ruling passion of my life,” he said simply. “I have lived but for science and in the hours where failure seemed certain and the cause of science lost, the thought of what science means to the world has upheld my courage.”

And in this speech he told his audience of some of the struggles he had to overcome. For five years he had worked against the disease which ravaged the silkworm, before he could show any results at all. For years more he worked on it and then was faced, once he had the proof, with the task of making the world believe in him.

It makes one wonder at the courage of the man, the fighting courage in the midst of overwhelming odds. Fifteen years spent in laboratory experiments; five of them without apparent result. Then, when the result did appear, it was not until years later that he was believed and thought anything but a fool or a crank.

But once the celebration was over and Pasteur was able to tear himself from his admirers, he went back to testing inoculation for splenic fever. Splendid results had been reported in checking the disease, but some of the sheepherders and uneducated farmers had scoffed at the idea of injecting serum into their cattle.

They had done more than scoff. Afraid, a little superstitious of this so-called "magic" which Pasteur exercised, many of them refused to allow their herds to be inoculated.

But the time came, too, when a celebration was held where farmers and scientists and surgeons alike poured out in the town of Gard to see the man who had saved this locality from the disease that was killing their cattle and sheep.

Pasteur was very tired when he was called on for a speech but as he walked on the platform and saw the hundreds of welcoming faces and the smiles of the farmers who had once held only despair in their eyes, a feeling of contentment settled over him and the weariness vanished.

Like all great men once recognized as such, he became attributed with almost supernatural powers. At the meeting, the Vice President of the Agricultural Society, after congratulating and praising Pasteur for the noble work he had done with splenic fever, said, "You have delivered us from the terrible scourge of splenic fever. Will you now, perhaps, turn your attention to the great enemy of all animal and plant life—rot?"

Rot in various forms had proved a bugbear to the farmers of the country since time immemorial. Nothing as yet had been ascertained as to its cause or prevention. It was in a way a tribute to the genius of Pasteur that someone should ask him in such an offhand way to find the solution. It is certain that there was no doubt in the speaker's mind that to ask was to be answered. No problem, he felt, was too great for Louis Pasteur to master.

There was, however, still some doubt in the minds of a few distrustful veterinary surgeons and especially among many of the shepherds as to the actual value of inoculation for splenic fever. Because of this distrust many

shepherds were allowing their cattle and sheep to die off rapidly, rather than take a chance on the magic.

To stop this, Pasteur made a challenge which everyone could understand.

Twelve cattle were brought in for experimentation. All were beginning victims of the splenic fever.

This was our knight's challenge!

"Of these twelve cattle," he said, "I will inoculate six with vaccine, the others will not be inoculated. Tomorrow the six which are not inoculated will be dead. The others will be healthy."

When the doubters came the next day, unbelieving eyes saw and believed, for five of the six not inoculated were already dead and the other dying. Of the six which had been treated with vaccine, all were living and healthy animals.

The life of Louis Pasteur was a constant series of battles partially won. Sometimes when he thought he had gained a victory a new challenger would break out. Sometimes these challengers were forms of disease, again they were attacks from people who were envious of his tremendous success or could not believe.

The sharpest attacks against him at this time came from Germany. A certain faction, under Dr. Koch, started a campaign against Pasteur. These men declared that Pasteur was incapable of cultivating microbes in a state of purity.

None of his experiments seemed to mean anything to them. They found ways to ridicule him in every manner, claiming that a great many of his experiments were impossible and impracticable. They even contested the preserving influence of vaccination. While this malicious campaign was going on, the Veterinary School of Berlin asked France for some vaccine.

Once the vaccine was proved to be all that was claimed for it, Pasteur was called to Geneva to attend the International Congress of Hygiene, and read a paper on attenuated virus. As a special compliment, the whole of one meeting was to be reserved for Pasteur only.

Pasteur received the invitation while he and his family were spending some time in the old home at Arbois. He was having some repairs made to the house and the old tannery pits were being filled up. "It will not improve the house itself," he wrote his son, who was now serving in the French

diplomatic corps, “but it will be more cheerful and homelike by having a beautiful yard and a garden along the riverside.”

Immediately Pasteur went to work preparing his paper for the Geneva Congress. The old laboratory notebooks and records were brought out and Pasteur worked steadily day after day. He consented, only after considerable pressure had been brought to bear on him by his wife, to take a walk along the Besançon road every afternoon at five o’clock. So absorbed did he become in his paper that he would brook no other interruptions—grumbled when he was asked about the contents of the paper. Mme. Pasteur, however, did succeed in copying the entire speech in her clear handwriting, from her husband’s little sheets covered with footnotes.

When Pasteur entered the hall at Geneva great applause greeted him from all sides.

Always in meetings at Geneva, because of the many languages spoken, there was a great deal of confusion and noise which made it difficult for the speaker. But when Pasteur stood up, the crowd of one accord became quiet. They not only recognized Pasteur as a great personage; they sensed a battle, for it was well known that Louis Pasteur would always fight for his principles when he knew they were right.

He did not go into classic oratory. He discussed the problem of attenuated virus as he believed in it. Before finishing he mentioned the names of several of the men who had directed the campaign against him.

> You have been kind enough to invite me to give my opinion before this group. There are those who disagree with me. Among them is Dr. Koch whose personal merit entitles him to our attention. They will allow me to invite him to speak. I shall be happy to answer them.

But when Dr. Koch came to the platform he refused to take a personal issue on the subject being discussed. “I would rather write up my opinion in a letter at a later date,” he temporized.

While Pasteur was definitely disappointed because of Dr. Koch’s evasion, he still considered it a moral victory; and a victory it was for our Knight of the Laboratory. For on the day he returned from Geneva he wrote a letter to his son in which he said: “All the honor was for France. That was as I had wished.”

It is significant to note that Louis Pasteur constantly was in communication with his family when they were not with him. He kept them informed of the progress of his experiments, his work, his triumphs. In many of his letters he expressed his sorrow that he could not be with them constantly. Mme. Pasteur and their remaining daughter, however, often accompanied him on his journeys and they witnessed many of his triumphs. His son and daughter were both married and the Pasteurs welcomed their daughter-in-law and son-in-law to the family circle with a love that was clearly evident. That Pasteur was fond of children is brought out by a famous portrait of him by Bonnet. This was painted when Pasteur was sixty-four years old and shows the scientist standing with his hand resting on the shoulder of his little granddaughter, Edelfeldt.

The little setbacks Pasteur had with scientists from time to time, and from those who sought to discourage him, could not keep his insatiable mind from wandering into other fields.

While the cheers of the meeting at Geneva were still ringing in his ears, he was already immersed in another battle; the fight against the “rouget” disease or swine fever!

Chapter XVII At Bollène

Louis Pasteur's interests were not confined to any one phase of science; the genius of the man was emphasized by the way his exploring mind went deep into the study of all types of disease and microorganisms.

The farmers of France and, in fact, in all of Europe during the year 1882 were being hit hard by a disease that was striking at their swine. Most of the land was divided into small parcels and the bulk of the farmers depended on the sale of their cattle and hogs to keep them from starvation.

The so-called "swine fever" was nothing new. For years it had taken a heavy toll from the farmers. Some efforts had been made by veterinary surgeons to check the spread of the disease, but little or nothing had resulted.

It required no urgent pressure on Pasteur to secure his services. Now, as always, his heart and brain were set afire by a desire to probe into the malady until some remedy could be found. It was a definite challenge and Pasteur wasted no time in accepting it.

The existence of a microbe which caused the disease now running wild among swine had already been discovered by Thuillier, a young French scientist. The question in Pasteur's mind was whether or not the microbe that Thuillier had was a direct cause of the fever. To know for sure, and as a first step, a culture medium had to be found which was suitable to the organism.

Veal broth, after much experimentation, was found to be the most successful culture medium. After the right culture had been established, a drop of the culture had to be abstracted from the little phials where the microbe was developing. This was placed into other flasks and lastly the culture liquid from the final process had to be inoculated into hogs.

In all cases where the culture was inoculated into hogs, the animals died, leaving no question in Pasteur's mind that the organism or microbe had been established as the cause of swine fever.

Think of the minute detailed work which hour after hour took the time and attention of Pasteur and his assistants. It is not enough to know that results were obtained. To see the picture truly, you must visualize Pasteur and his assistants working day after day, night after night, with but one thought in their minds—how to control these inoculations.

Now came the question of whether a vaccine could be discovered that would counteract the terrific spread of the microbes.

M. Maucer, a veterinary surgeon in the town of Bollène, had been pressing Pasteur to discover a remedy for the disease which was taking unusually heavy toll in his vicinity. More than twenty thousand hogs had died in this district within a very short period of time. This gives an idea of the extent of the malady which was spreading alarm and starvation over the country.

On September 13, 1882, Pasteur left Paris, where he had been working on experiments, and together with Thuillier and his nephew, Adrien Loir, arrived at Bollène.

"Now that you are here," Maucer exclaimed, "our fears can be banished."

The Maucers were ideal hosts. The best of their house was given to Pasteur and his assistants.

Pasteur reproached Maucer for giving up his rooms. "The three of us can easily secure rooms at the hotel. There is no reason why we should take over your home."

Maucer smiled. "Aside from my own sincere wishes," he said, "my wife would not speak to me again if I did not do everything in my power to make things easier for you."

"But it isn't necessary," Pasteur argued.

"You have it in your power to conquer a disease which is rapidly threatening the hopes of every farmer in the vicinity," Maucer said gravely. "Poverty and death and starvation are threatening from all sides, reaching in on us, clutching at us. You, in the greatness of your heart and the love of your profession, are willing to make an effort to alleviate our condition. Could there then be anything too much that we might do?"

The situation as Pasteur found it was much to his liking. In many of the calls for help which he received before coming to Bollène, the ravages of the disease had spent itself. There had been no good material at hand and Pasteur had been forced to work to the utmost to find material enough for research.

But here in Bollène the swine fever was at its height. Natives called it "swine fever" but more often "rouget" or "red fever." The origin of the name is easily understood. In the advanced stages of the disease the hogs were a

mass of red and purple blotches and in this stage they spread the disease at an enormous rate.

Sick hogs were everywhere. At Bollène, farmers and citizens were desperate. To Pasteur they came daily. Dread and suffering showed in their eyes. The farmers' incomes were being swept away in that terrible epidemic. They could not buy because they had no money with which to purchase the things they needed.

Here, as everywhere, the farmer, the merchant and the housewife were all dependent on one another. If the farmer lost his swine, the housewife could not have meat for the table, the farmer had no money and could buy nothing at the stores, so the merchants suffered along with the rest.

Again it was a challenge to Louis Pasteur. The greatness of the man lay in the multiplicity of his interests. Disease in any form and anywhere seized his attention. Not satisfied with being merely a benefactor to man in the preservation of man's life, he had gone on and on, fighting at every step. But for him, the silkworm industry in France would have been ruined. But for his work on splenic fever in cattle and sheep, thousands would have been bankrupt. He had distilled hope and a new faith; he had kindled a new courage in the hearts of frightened people.

How easy now for him to rest on his laurels. Already in his span of life he had accomplished miracles. Years before he could have said, "I've made a reputation and I have enough money and glory. Why shouldn't I sit down and let someone else do the work and the worrying?"

Many scientists of the day were doing that, devoting their time to one phase of scientific discovery and, after achieving that, resting on their glory and basking in the limelight of the court of France.

But Pasteur would not have been a true Knight of the Laboratory had he, when the silkworm industry had been saved, said, "I've done enough. Let others do the rest."

Again you must understand it wasn't merely a question, great as Pasteur was, of being given a problem, solving it and then moving on.

Setbacks and heartaches of every type came along. It was enough to discourage the strongest heart and the keenest brain. Much of his work seemed done for no purpose; but over and over again he experimented far into the night, week after week, month after month.

Just as a boy in school with a difficult problem that he cannot solve often does, Pasteur might have said, "Let it go until tomorrow or next week. By

then maybe it will come easier to me. In the meantime I will have some fun out of life."

Despite the fact that Pasteur undoubtedly secured much enjoyment out of his experiments, there was much drudgery and hard work connected with them. Disappointments followed disappointments, piled up on each other until the weight of them seemed more than he could bear.

Along with this were the temptations to be avoided. The wealthy and important people of Bollène knew they had a great personage in their midst. Every day they besieged him with admiration and praise, asking him to their homes, offering pleasure and amusement and personal glorification.

Had his will been less strong, Pasteur might easily have weakened. After all, it is much easier to stroll among people who worship you, to bask in the smile of fortune instead of rolling up the shirtsleeves and getting down to work.

Dead and dying swine were everywhere in evidence. Walking anywhere in the country, Pasteur could see the evidences of the ravages of the disease. At every turn farmers and farmers' wives, with tears in their eyes and misery in their hearts, begged him to help them, thanked him for what he had done.

One morning a young hog on the verge of death was brought into the ready-made laboratory. The hog was the last of a certain farmer's stock. Of the several hundred hogs he had owned a few months before, only this had survived and this one was dying.

Two months before, the farmer had been all smiles, for with the stock he could sell in the fall of the year, his wife and children would have food and shelter and warmth for another winter, perhaps even a few amusements and toys.

But in one fatal stroke, all this had been washed away and with it had gone hope and contentment. Misery burned in his eyes. Instead of seeing happiness and plenty for his family, all he could see now was empty cupboards, a cold winter with no fuel. He could see the patient resignation in his wife's eyes, could hear the hungry wails of the children.

To whom could he turn? Any assistance that was offered him was only temporary. A meager credit at the village store, a loaf of bread from the parish priest, perhaps a small loan from a neighbor in slightly better circumstances. Actually, what help of this kind he received could not and did not compensate him for his loss, for that loss represented years of work. No one knew better than he how true this was. How slowly a profitable herd

is built up. All the thought and labor that is involved in selecting and breeding, housing and feeding the swine.

In his heart there was bitterness, no doubt, over the inability of his Government or any human agency to help him. And this man, Pasteur, of whom so many incredible tales had been told—could even he do anything in such a crisis? Very unlikely. How could he succeed when so many others had failed? Yet to Pasteur his pleas went, by letter and word of mouth, and their urgency mounted until, in the composite, they became a single call reverberating across the land:

"Help us, in the name of God!"

It was this sort of pressure under which Pasteur worked. On the surface he might seem to those who did not know him a hard-bitten scientist, careless of life or death, living only to create a name for himself.

But under all this surface was a warm heart that beat in sympathy with the French people, a soul that cried out at the suffering they must endure.

For above all, Louis Pasteur was a great man, an understanding soul and a gentleman, and he knew that such misery must not continue.

Chapter XVIII A Supreme Sacrifice

After several months of laborious experiments, patiently waiting for the desired result, Louis Pasteur wrote a letter to his wife, one of his many letters set down upon the loose pages of a laboratory notebook.

> Swine fever [he wrote] is not nearly so hidden to me now and I am convinced that with the passing of time, the scientific and practical problem will be solved.
>
> Three post mortems today. They take a long time but that seems of no account to Thuillier, with his cool and patient eagerness.

Cool and patient eagerness. That phrase might have equally been applied by Pasteur to himself. Eager he was, like a greyhound tugging at the leash, ready to project his body down the road with blinding speed. Cool, too. Such excitement as ran riot in his veins he had learned to control under a mask of indifference. As the surgeon's hand must be steady with the scalpel, so was Pasteur's mind. Cool and poised and ready to pounce on anything that looked as though it might be of value in his experiments.

A few days later he wrote to his wife again.

> I am very sorry to inform you that I am not starting back for Paris. It is just about impossible to abandon all these experiments which we have begun; I should have to come back here at least once or twice. The main thing is that things are getting clearer with every experiment. You know that nowadays mere medical

knowledge of disease is not enough; it must be prevented beforehand. We are attempting this and I think I can foresee success; but keep this for yourself and our children.

So from the salvation of the wine industry, the silkworm industry, the salvation of man, Louis Pasteur moved with patient celerity to the "salvation of pigsties."

His letter to the Academy of Science was a masterpiece of exactness and modesty, characteristic of the man. Note how entirely he eliminates himself from the discussion.

> The swine fever, or rouget disease, is caused by a certain microbe, easy of cultivation outside of the animal's body. It is so small that it often escapes the most intense search. It resembles the microbe of chicken cholera more than any other; its shape is also that of a figure "eight," but finer and less visible than that of cholera. There is an essential difference from the latter in its physiological properties; it kills rabbits and sheep, but it has no effect on hens.
>
> If inoculated in its pure state into pigs, it quickly causes fever and death. It is most deadly to the white, so called improved race, which is most desired by pork breeders.
>
> Though we think that further control experiments are necessary, we already have great confidence in this, that, dating from next spring, vaccination by the virulent microbe of swine fever, attenuated, will become the salvation of pigsties.

In still another letter, Pasteur revealed that he possessed a rare sense of humor, not usually associated with a scientist.

> We are starting tomorrow, Monday. Adrien Loir and I shall sleep at Lyons. Thuillier will go direct to Paris, to take care of ten little pigs which we have bought. In this way they will not be kept waiting at stations. Pigs, young and old, are very sensitive to cold so we will wrap them up in straw. They are very young and quite charming; one cannot help liking them.

The discoveries of Pasteur were to become a great boon in pork-breeding countries. In the United States more than a million swine died of this disease in 1879. It was raging in England and Germany.

His experiments in Bollène ended, Pasteur returned to Paris. The vast strain to which he had been subjecting his body and brain demanded that he have a rest. An older man does not have the stamina of the younger man. Pasteur was physically and mentally tired. Friends urged him to retire—to at least take a long rest.

Dumas was particularly urgent. "You are driving yourself beyond the limit of endurance," he warned. "Your body will not stand the pressure you are exerting."

Pasteur looked at him thoughtfully and shook his head. "Perhaps. Perhaps you are right," he replied quietly. "But somehow it would seem to me that I was committing a theft if I were to let one day go by without doing some work."

Meanwhile in Germany, Koch, the scientist, was still doing his best to cast discredit on Pasteur's discoveries.

Shortly after Pasteur had finished his work at Bollène, Koch wrote a paper, slightly modifying his former views but maintaining that he still could not see the practical results of the vaccination of sheep.

But Pasteur, happily, had proof by now.

The sheep vaccinated in Eure-et-Loir during the last year formed a total of 79,392. Instead of a mortality which had been more than nine per cent on the average in the last ten years, the mortality had been only 518 sheep, much less than one per cent; 5,900 sheep had therefore been preserved by vaccination.

Among cattle 4,562 animals had been vaccinated; out of a similar number three hundred usually died each year. Since vaccination, only eleven cows had died.

But Koch, though he might have been convinced, was jealous, and maintained his critical comments on Pasteur's work.

In the meantime, testimonials of gratitude continued to pour in upon Pasteur from the agriculturists and veterinary surgeons who had seen the results of two years' practice of the vaccination against anthrax.

In the year 1882, 613,740 sheep and 83,946 oxen had been vaccinated. The Department of the Cantal, which had before lost about three million francs every year, gave Louis Pasteur a special acknowledgment of gratitude. It consisted of a cup of silver-plated bronze, ornamented with a

group of cattle. Behind the group of cattle was represented an instrument which had been raised to an exalted position, the little syringe used for inoculations.

At a special meeting of physicians Dr. Fleys, head doctor of the Aurillac Hospital, said, in proposing a toast to Pasteur: "What the mechanism of the heavens owes to Newton, chemistry to Lavoisier, geology to Cuvier, general anatomy to Bichat, physiology to Claude Bernard, pathology and hygiene will owe to Pasteur."

In the first rank of Louis Pasteur's admirers came the scientists, who more than anyone else lauded the achievements of a man whose perseverance had equaled his penetration for more than thirty-five years.

Huxley, in a public lecture at the London Royal Society, said: "Pasteur's discoveries alone would suffice to cover the war indemnity of five millions paid by France to Germany in 1870."

To that capital was added the inestimable price of human lives saved. Since the antiseptic method had been adopted in surgical operations the mortality had fallen from fifty out of a hundred to five out of a hundred.

Pasteur had given France and the world definite proof that the germs of disease could be destroyed by the culture from those selfsame disease organisms after the patient or sufferer had been inoculated. A challenge had been tossed at him. With his characteristic zeal and fervor he had accepted the challenge and won. Hygiene was at last taking its place in the public view. France was proud of him. His powerful mind, allied with his very tender heart, had brought glory and charity of mind to France.

But there remained still one more incompleted work that for years had intrigued Pasteur. It was the checking of hydrophobia. Earlier experiments had convinced him that it could be controlled as effectively as other contagious disease. Wasting no time after returning to Paris from Bollène, he at once plunged into further experiments.

He and Thuillier, the scientist who had worked with him at Bollène, had become very great friends. Whether or not Pasteur had intended to bring Thuillier in with him on his study of hydrophobia is not known, for scarcely had Pasteur become immersed in his studies when an epidemic of cholera broke out in Egypt.

At first a majority of members of the Alexandria Safety Council were agreed that the cholera was not virulent and strongly opposed any and every effort to quarantine the country. In this view they were supported by a

British and native sentiment that could see in the early stages of the epidemic no particular cause for alarm. But as the cholera spread unchecked the Safety Council was compelled to revise its earlier opinion. How much better it would have been to put down the quarantine before the disease had spread.

And how quickly it was spreading! By July 14 it had reached Cairo, Egypt. Between the fourteenth and twenty-second of the month there were five hundred deaths a day. Then Alexandria was threatened. On and on, the ghost of the new horror stalked grimly across the land, spreading death and destruction in its path.

It was then that Pasteur, alert to what was going on, suggested the forming of a French scientific mission to Alexandria. Not only did the French Committee of Hygiene approve of Pasteur's project but they asked him to choose some young men whose knowledge would be equaled by their devotion.

It was interesting to notice the about-face attitude that France and the world had taken in their regard for Louis Pasteur. At one time scorned and ridiculed for his supposedly silly ideas and experiments, now the public swarmed to his banner.

Out of the group of young scientists of the day, Pasteur had his pick, all of them eager to join the fight against cholera. Louis Thuillier was one of them, as he had become a devoted follower of Pasteur. He asked, however, for twenty-four hours' leave.

The reason for his request was to say farewell to his father, mother and sister. He told his father of his intention but not his mother nor his sister. At the time, however, the papers were filled with the news of the French Commission to study cholera and his sister, after reading a paper, suddenly jumped up and said:

"Promise me, Louis, promise me that you are not going to Egypt! Swear that you are not!"

"I am not going to swear anything," her brother answered and then added, "Perhaps I might go to Russia to direct vaccinations against anthrax."

The subject dropped there. The family said no more. When he left home, nothing in his farewells showed his deep emotion. There was in him a strong love for his family; but a situation had arisen that meant more than his family, more than himself. There was but one answer.

At Marseilles, ready to embark for Alexandria, Thuillier wrote his family of his decision, stating that he was actually on his way. It was a letter of cheer and tenderness that helped to soften the shock of actual separation.

In Alexandria the Commission of young disciples of Pasteur set to work with all the freshness and vigor that was characteristic of their master.

What was the cause of cholera?

The most varied modes of culture were attempted in vain. The same negative results followed inoculations of cats, dogs, swine, monkeys, pigeons, rabbits and guinea pigs. Frantically these men worked, putting every bit of physical and mental vitality into the problem before them.

And then quite suddenly the epidemic ceased. As rapidly as it had begun it stopped and the Commission was handicapped at arriving at any further solutions because of lack of experimental material.

While marking time, waiting for a possible reappearance of the epidemic, the French Commission took up some research work on the cattle plague.

But scarcely had they commenced when Pasteur received a communication which made him sick at heart.

Thuillier, the scientist whom Pasteur had come to love and respect, had died in Alexandria of cholera.

The blow struck Pasteur hard. In his scientific studies he had very little opportunity to cultivate friendships. But Thuillier, the young scientist, had meant much to him.

Thuillier was only twenty-six years old when he succumbed to cholera. How had this happened? Had he neglected any of the precautions which Pasteur had written down before the departure of the Commission?

Pasteur remained silent all day following the receipt of the telegram. He was absolutely overcome.

Later he received more detailed information. Remaining in Alexandria, Thuillier had gone to bed one night at ten o'clock, apparently in perfect health. At three in the morning he became suddenly ill. At eight o'clock all the horrible symptoms of the most violent form of cholera were apparent and his friends gave him up for lost.

On Pasteur, the experimenter and scientist, death should not have had a great effect. He worked constantly in the presence of death or the threat of death. And yet the death of young Thuillier left him grief-stricken for months after. A scientist has a heart after all.

Still keeping on at his experimental work in his own laboratories, Pasteur was now besieged by everyone. He received letters of praise and commendation from all parts of the world. Important personages came to him for consultations, as if he were a doctor.

Many people, not understanding the work he was doing, did take him for a physician and could not understand when they were told by friends of

Pasteur that he did not cure individuals.

He was only trying to cure humanity.

Universities honored him with degrees. Glory was heaped on him from every part of the world. At the University of Edinburgh, in Scotland, when he came forward to receive his honorary degree, five thousand people rose to greet him and burst into spontaneous applause.

But all this time, with the exception of the few occasions when Pasteur allowed himself to be dragged away to banquets and presentation ceremonies, he was still working on the cure for hydrophobia.

It was the one mystery that constantly haunted his mind; he could not rest until he had solved the problem of the bite of the mad dog.

Experimentation of one sort or another had been undertaken by many scientists for a good many years, but practically nothing had been discovered in the treatment of what came to be known as rabies.

The first two mad dogs brought into the laboratory were given to Pasteur in 1880 by Bourrel, an old army veterinary surgeon who had long been trying to find a remedy for hydrophobia. He had invented a preventative measure which consisted in filing down the teeth of the dogs, so that they should not bite into the skin.

One of the two dogs he sent was suffering from what is called “dumb madness”; his jaw was paralyzed and hung half open, his tongue was covered with foam and his eyes were full of wistful anguish. The other dog made ferocious lunges at anything held out to him with rabid fury in his bloodshot eyes, and in the height of his delirium gave vent to haunting, despairing howls.

Much confusion prevailed regarding this disease, its cause and remedy. Three things seemed certain: first, the rabic virus was contained in the saliva of the mad animals; second, it was contracted through bites; third, the period before results showed might vary from a few days to several months.

Pasteur was advised that a five-year-old child, bitten on the face a month before, had just been admitted to the hospital. The child had all the symptoms of hydrophobia: spasms, restlessness, a deep thirst, convulsions, fits of furious rage.

The child died within twenty-four hours. Pasteur gathered some of the mucus from the mouth of the dead child, mixed it with water and inoculated

the solution into some rabbits, all of which died within less than thirty-six hours.

Pasteur then examined under a microscope the blood of the rabbits which had died and found a new microorganism.

That in itself meant little to Pasteur. New organisms of one kind or another were now being uncovered by many scientists. But the question arose in his mind whether this or some other microbe could be associated with the rabic saliva.

He kept on experimenting with the saliva from other patients who had died from hydrophobia, working long into the night until he was so weary he could not see.

People, learning of his experiments, laughed as they had laughed at him before.

"What do we want with a new disease?" they said. "We have enough of them now. Why go about looking for trouble?"

But Pasteur was born to look for trouble, trouble that could be eliminated by study and in so doing save lives and give happiness.

There was much danger in his work but Pasteur never thought of it from the angle of danger. One day he and two assistants took a mad bulldog, foaming at the mouth. They seized it with a lasso and stretched it on the table. The two men held the furious animal down while Pasteur drew with a glass tube, held between his lips, a few drops of the saliva from the dog's mouth.

But somehow or other the culture did not work and once again Pasteur was defeated. Ready to quit?

When anyone suggested quitting, Pasteur would look at him. "We haven't really started. This may take months, years, but if we can accomplish our end, the world will be the better for our efforts."

As he tried more and more cases, he felt a growing conviction that hydrophobia had its seat in the nervous system.

In one post-mortem case, the brain of the mad dog was uncovered and a particle of the brain substance was drawn into a tube previously put through a flame. The contents of the tube were then placed in a glass just taken from a stove heated to two hundred degrees centigrade. To this was added some boiling water or sterilized broth. The animals to be tested were then

inoculated with this mixture and most of them succumbed to hydrophobia. This mixture, then, was more successful than the saliva.

Pasteur was advancing step by step. But even to him the steps he was now making were discouraging. Many others would have given the search up as hopeless.

It then occurred to Pasteur to inoculate the rabic virus directly on the surface of a dog's brain.

The experiment was attempted. A well dog under chloroform was fixed to the operating board and a small injection of the virus was placed directly into the brain cavity of the dog. The wound was washed with carbolic acid and the skin stitched together, the whole operation lasting but a few minutes.

On returning to consciousness, the dog seemed quite the same as usual. But after fourteen days, hydrophobia occurred—rabid fury, characteristic howls, the tearing up and devouring of his bed. From there it went into the final stages of paralysis and death.

Now Pasteur knew he had discovered something. He had discovered a way in which rabies could be contracted surely and swiftly.

The same thing was tried again and again. Always the dog was chloroformed. Pasteur had a horror of useless suffering and it was only in the interest of curing a disease for many that he would use animals for subjects.

Pasteur became slightly excited when in a dozen or more experiments the same result occurred.

He turned his attention to experiments on rabbits. The secret of creating a vaccine that would successfully counteract rabies was to develop a rabies vaccine, not so powerful as the disease germs but sufficiently strong, when inoculated, to make the patient immune to rabies or, when the disease had been contracted responsive to a cure.

As soon as an inoculated rabbit died paralyzed, Pasteur took some of the virus and injected it into still another rabbit and another and another until after a hundred inoculations he had reduced the time the disease's symptoms showed to seven days.

Pasteur was tremendously elated. With his analytical mind he knew that he had almost mastered the problem. He might not be able to predict the exact time when death should occur in each of the inoculated animals, but he

could tell exactly when the symptoms would commence. His task was half completed.

Now he took a fragment of the brain of a rabbit which had died from inoculation. He suspended it on a thread in a sterilized bottle. The air in the bottle was kept dry by some pieces of caustic potash lying at the bottom of the glass. The temperature of the room was kept at twenty-three degrees centigrade. As the fragment became dry, its virulence decreased until at the end of fourteen days it had become absolutely harmless.

Then Pasteur took the inactive virus and crushed and mixed it with pure water and injected the mixture under the skin of some dogs.

The next day they were inoculated with thirteen-day-old virus and so on, increasing the virulency of the potion with each inoculation, until the final inoculation was that of virus from a rabbit that had died the same day. On testing, he found that these vaccinated dogs could now be bitten by a dog with the rabies or could be treated by inoculation of the rabies germ and resist both. Louis Pasteur had won partially at least.

Then and not until then did Pasteur dare to write down his conclusions on a paper which he read to the Academy of Science.

His speech caused considerable excitement but, as always, along with the excitement came skepticism.

And then one day, a month or two later, nine-year-old Joseph Meister was brought to Pasteur by his mother.

The child, going alone to school two days before, had been attacked, thrown to the ground and bitten by a mad dog. Too small to defend himself, he had only thought of covering his face with his hands. A bricklayer saw the occurrence and succeeded in beating off the dog with an iron bar.

The dog went back to his master and bit him in the arm and his master shot him. When the dog's stomach was examined it was found to be full of hay, straw, pieces of wood.

The boy had fourteen bites and had been given up, as everyone knew that sooner or later he must develop rabies and die.

Pasteur, however, did not come to an immediate decision. His emotion was profound as he looked at the boy who could hardly walk because of his wounds. What should he do? Should he risk trying the same treatment on the boy which had been tried on dogs? "Oh, God, direct me," Pasteur prayed. He consulted with his colleagues, Grancher and Vulpian, who both

contended that the treatment would be just as effective on human beings as on dogs.

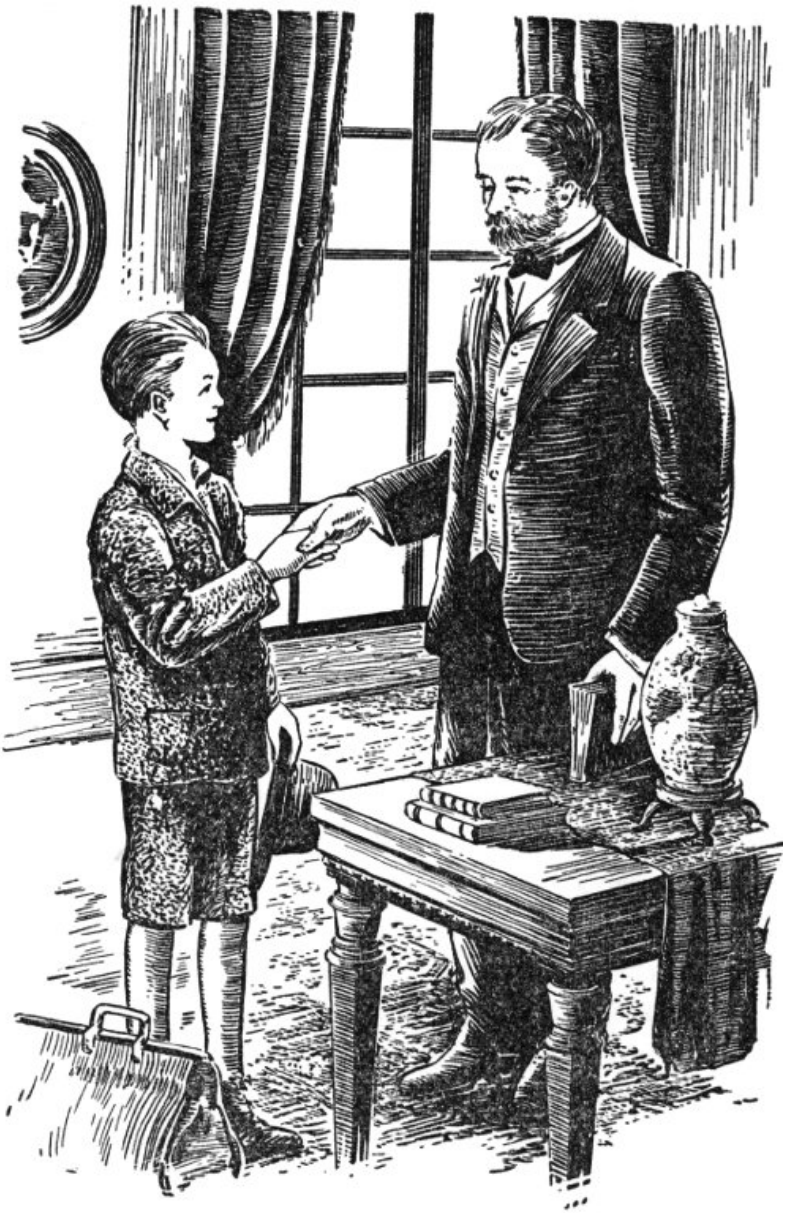
Having made his decision, Pasteur lost no time. An injection was made into the child's side, a few drops of a liquid prepared from fragments of a rabbit's brain.

It was a great moment for Pasteur and yet a moment when life trembled in the balance. There had never been a case of hydrophobia from which a human being had recovered, though animals sometimes had. And here was a victim who had been bitten two days before. The chances of success were slim.

Each succeeding inoculation was made with a stronger vaccine. Pasteur was going through a succession of hopes, fears and anguish. He had a great yearning to snatch the Meister boy from death. For once in his life Pasteur knew concentration at its most sublime heights.

At nights, feverish visions came to him of this child whom he had seen playing in the garden. Pasteur could scarcely eat during the process of vaccination and night after night he tossed restlessly in his bed.

The treatment lasted ten days. The Meister boy was inoculated twelve times and withstood each inoculation even better than Pasteur had expected.



But the boy lived and was perfectly healthy. The remedy for hydrophobia had been found.

For the last inoculation Pasteur used some of the one-day-old vaccine. The boy was no longer afraid of him. His face showed neither fear nor shyness. After the inoculation he closed his eyes and slept peacefully.

But not so Louis Pasteur. Pasteur spent a terrible night of insomnia. In those slow dark hours, for a time he lost faith in himself and thought the boy would die.

But the boy did not die. He lived and was perfectly healthy. It was then that Pasteur gave thanks to Almighty God. He knew now that the remedy for hydrophobia had been found.

More cases of hydrophobia were sent to him and all of them responded. One of the crucial cases was a shepherd boy who had been bitten by a mad dog and had not come for treatment for seven days after the bite.

When this boy lived, Pasteur knew that the fight was won and immediately set out to organize dispensaries for the prevention of rabies.

For many years after this Louis Pasteur was active in speaking for and defending his discoveries and, despite his advancing age and the beginning of serious ill health, he was still delving into new experiments.

When Pasteur grew gravely ill, the nation became concerned. How willingly would thousands and millions of people have given a moment of their lives to prolong his; those thousands of human beings whose existence had been saved by his methods; sick children, women in lying-in hospitals; patients operated upon in surgical wards; victims of rabid dogs saved from hydrophobia.

In those last months it was known for the first time to what an extent Pasteur's reputation had grown beyond national limits. His great works had passed over the boundaries of France to consolidate a new empire of health and progress that included every country upon this earth. So at his bedside a grateful, all-inclusive humanity watched. London paused reverently to receive word of him, as did Vienna and Rome. Silent messages poured to him from Australia, India, China, Russia and the United States. Near or far away, all lands and all people were as one in their deep and sincere wishes for his hurried recovery.

During his illness, so many Pasteurians, disciples and followers of Louis Pasteur, volunteered to watch at the bedside of their beloved master that it was impossible to accommodate all of them. The fortunate ones were arranged in shifts and each one, together with a member of the family, would act as a nurse for a certain number of hours. How these young Pasteurians gloried in being of service to him whose name would reverberate down through the ages! And sometimes, at midnight, Pasteur's beloved wife would enter the sick room and dismiss the willing nurses so that she could

silently gaze at the features she loved so well. Perhaps she could not refrain from shedding a tear, yet she must have been given fresh courage when she thought that there on the bed was not only her husband but one whose name and fame would be immortalized in the hearts of millions.

At the end of December, the indomitable, fighting courage of our Knight was aroused to enable him to leave the sick bed where he had been for a month. Accompanied by Dr. Roux, he once again entered the laboratory where a surprise awaited him. There, on a large table, were arranged first the flasks he had used in his memorable trip to the Alps and which finally, once and for all, silenced his opponents who held to the theory of spontaneous generation; there were the rows of tubes used for his studies on wines, beer, vinegar; test tubes containing vaccines against anthrax, cholera, diphtheria, bubonic plague, hydrophobia and many other culture mediums—all unknown before Pasteur's time, all reminding him of the battles he had fought with those who would not believe, who thought him a fool, a dreamer, a meddler, and all the result of his own laboratory experiments and those of the Pasteurians who were carrying on his work. Triumphantly he viewed all this and triumphantly he left the laboratory.

The following summer found Pasteur growing weaker and weaker. His physical strength was slowly ebbing, though his moral energy and keenness of mind were as active as ever. Most of his time was spent in the yard of the new Pasteur Institute which had been erected from popular subscriptions sent from all parts of the world. Then it was thought best to move him to the Villeneuve l'Etang in the country and here again he spent many hours under the shade trees in the yard. Here his beloved wife or daughter would read to him. Biographies were his favorites and while at first he evinced interest in those of the Napoleonic era, gradually his liking for the life of St. Vincent de Paul took precedence over all else. Again and again he requested that passages from this great saint's life be read to him. Possibly he recognized a parallel between his own life dedicated to the preservation of humanity and that of the peasant's son who gloried in a life of sacrifice for the poor.

On Saturday, September 28, 1895, our Knight of the Laboratory went to his eternal reward. But even death could not separate from humanity this mortal man whose accomplishments would live on and on in the hearts of a grateful people; passing years will not triumph over that unselfishness that encompasses the boundaries of time; that great spirit is unconquerable—it has and will inspire thousands of young physicians, scientists, nurses to emulate our lovable, courageous, indomitable Knight of the Laboratory.

TRANSCRIBER NOTES

Mis-spelled words and printer errors have been corrected. Where multiple spellings occur, majority use has been employed.

Punctuation has been maintained except where obvious printer errors occur.

[The end of *Pasteur, Knight of the Laboratory* by Francis E. Benz]