THE MESSAGE OF LEONARDO

HIS RELATION TO THE BIRTH OF MODERN SCIENCE

By George Sarton

LEONARDO DA VINCI died in the little manor of Cloux, near Amboise, where he had been for the last three years the honored guest of Francis I, on May 2, 1519, that is exactly four hundred years ago. He was not only one of the greatest artists, but even more the greatest scientist and the greatest engineer of his day. Indeed, with the passing of time his unique personality looms larger and larger and bids fair to attain, as soon as it is completely known, gigantic proportions.

The most befitting way of celebrating with our Italian friends this four hundredth anniversary is to try to explain this mysterious personality. If he was not a miracle, we must be able to show how he came to be what he was. Leonardo the artist is so well known that I shall hardly speak of him, but it is worth while for the purpose that I have in mind briefly to recall the most important facts of his life.

He was born in Vinci, a village in the hills between Florence and Pisa, in 1452, an illegitimate child, his mother being a peasant woman, and his father Ser Piero, a notary, a man of substance. The latter's family can be traced back to 1339, along three other generations of notaries. Soon after Leonardo's birth, his father took him away from his mother, and both parents hastened to marry, each in his own set. Ser Piero must have been a man of tremendous vitality, mental and physical. He was one of the most successful notaries of the Signoria and of the great families of Florence, and his wealth increased apace. He married four times, the two first unions remaining childless. His first legitimate child was not born until 1476, when Leonardo was already twenty-four, but after that ten more children were borne to him by his third and fourth wives, the last one in the very year of his death, which occurred in 1504, when he was seventy-seven.

Thus Leonardo had five mothers. The real one disappears soon after his birth; she bore him and her mission ended there as far as Leonardo was concerned. What the four others were to him, we do not know, for he does not speak of them. He had five mothers and he had none. He is a motherless child, also a brotherless one, because he does not seem to have had much to do with his eleven brothers and sisters—far younger than himself anyhow—except when, at their father's death, they all leagued themselves against him to deny him any part of the patrimony. A motherless, brotherless, lonely childhood, we cannot lay too much stress on this; it accounts for so much.

In or about 1470 Ser Piero placed his son, now a very handsome and precocious boy, in the studio of Andrea Verrocchio, who since Donatello's death was the greatest sculptor of Florence; also a painter, a goldsmith, a very versatile man, indeed. Within the next years Leonardo had the opportunity to show the stuff of which he was made, and by 1480 his genius had matured. He was considered by common consent a great painter, and moreover his mind was swarming with ideas, not simply artistic ideas, but also architectural and engineering plans.

Leonardo was born in the neighborhood of Florence and bred in the great city. It is well, even in so short a sketch, to say what this implies. The people of Tuscany are made up of an extraordinary mixture of Etruscan, Roman, and Teutonic blood. Their main city, Florence, had been for centuries a considerable emporium, but also a centre of arts and of letters. Suffice it to remember that of all the Italian dialects it is the Tuscan, and more specifically its Florentine variety, which has become the national lan-

guage. The prosperous city soon took a lively interest in art, but loved it in its own way. These imaginative but cool-headed merchants patronize goldsmiths, sculptors, draftsmen. They do not waste any sentimentality, neither are they very sensual: clear outlines appeal more to them than gorgeous colors. Except when they are temporarily maddened by personal jealousy or by a feud which spreads like oil, it would be difficult to find people more level-headed, and having on an average more common sense and a clearer will.

Leonardo was a Florentine to the backbone, and yet this environment was not congenial to him. He was distinctly superior to most of his fellow citizens as a craftsman, but he could not match the best of them in literary matters. The Medici had gathered around them a circle of men whose delight it was to discuss topics of Greek, Latin, and vernacular literature, and to debate, often in a very learned manner, the subject of Platonic philosophy. There is no gainsaying that these Neoplatonists were a brilliant set of men, but their interests were chiefly of the literary kind; they were men of letters and loved beautiful discourse for its own sake. On the contrary, young Leonardo, following an irresistible trend, was carrying on scientific and technical investigations of every sort. The engineer in him was slowly developing. Perhaps, he could not help considering these amateur philosophers as idle talkers; but it is just as likely that, being a motherless child, he was not endowed with sufficient urbanity to fare comfortably in this society of refined dilettanti. Nature more and more engrossed his attention, and he was far more deeply concerned in solving its innumerable problems than in trying to reconcile Platonism and Christianity. Neither could his brother artists satisfy his intellectual needs; they were talking shop and fretting all the time. A few had shown some interest in scientific matters, but on the whole their horizon was too narrow and their self-centredness unbearable. Also, Florence was becoming a very old place, and an overgrowth of traditions and conventions gradually crowded out all initiative and real originality. So Leonardo left and went to Milan, to the court of Ludovico Sforza, at that time one of the most splendid courts of Europe. Milan would certainly offer more opportunities to an enterprising and restless mind like his. The very desire of outdoing Florence was a tremendous impulse for Ludovico: he was anxious to make of his capital a new Athens, and of the near-by university town of Pavia a great cultural centre. His happiest thought perhaps was to keep around him two men who were among the greatest of their day—Bramante and Leonardo. The liberal opportunities which were offered to these two giants are the supreme glory of the Sforza and of Milan.

Leonardo was employed by the Duke as a civil and military engineer, as a pageant master, as a sculptor, as a painter, as an architect. How far he was understood by his patron it is difficult to say. But he seems to have thriven in this new atmosphere, and these Milanese years are among the most active and the most fertile of his life. He was now at the height of his power and full scope was given to his devouring activity. It is during this period, for instance, that he modelled his famous equestrian statue of Francesco Sforza, that he painted the "Virgin of the Rocks," and the "Last Supper," while he was also superintending important hydraulic works, and pursuing indefatigably his various scientific investigations. Yet even at this time of greatest activity and enthusiasm he must have been a lonesome man. This brilliant but very corrupt court was of course the rendezvous of hundreds of dilettanti, parasites, snobs —male and female—and what could Leonardo do to protect himself against them but be silent and withdraw into his own shell?

Milan justly shares with Florence the fame of having given Leonardo to the world; it was really his second birthplace. Unfortunately, before long, heavy clouds gathered over this joyous city, and by 1500 the show was over and Ludovico, made prisoner by the French, was to spend the last ten years of his life most miserably in the underground cell of a dungeon. From that time on Leonardo's life became very unsettled. It is true, he spent many years in Florence, employed

by the Signoria, painting the "Gioconda" and the "Battle of Anghiari"; then for some years he was back in Milan, but he is more and more restless and somehow the charm is broken. After the fall of the Sforza, Isabella d'Este, Marchioness of Mantua—perhaps the most distinguished woman of the Renaissance—tried to attach Leonardo to her service, but he refused, and instead he chose, in 1502, to follow Cesare Borgia as his military engineer. One may wonder at this choice, yet it is easy enough to explain it. At that time Leonardo was already far prouder of his achievements as a mechanic and an engineer than as a painter. It is likely that in the eyes of Isabella, however, he was simply an artist and he may have feared that this accomplished princess would give him but little scope for his engineering designs and his scientific research. On the other hand, Leonardo found himself less and less at home in Florence. The city had considerably changed in the last ten years. Savonarola had ruled it, and many of the artists had been deeply swayed by his passionate appeals, and even more by his death. For once, fair Florence had lost her head. And then also, young Michael Angelo had appeared, heroic but intolerant and immoderate: he and Leonardo were equally great but so different that they could not possibly get on together.

In 1513–15 Leonardo went to the papal court, but there, for the first time in his life, the old man was snubbed. Having left Rome, his prospects were getting darker, when fortunately he met in Bologna the young King of France, Francis I, who persuaded him to accept his patronage. The King offered him a little castle in Touraine, with a princely income, and there Leonardo spent in comparative quietness, the last three years of his life. It must be said to the credit of Francis I that he seems to have understood his guest, or at least to have divined his sterling worth. France, however, did not appreciate Leonardo, and was not faithful to her trust. The cloister of Saint-Florentin at Amboise, where the great artist had been buried, was destroyed by a fire in 1808, and his very ashes are lost.

He was apparently an old man when he died, much older than his years, exhausted by his relentless mind and by the vicissitudes and the miseries of his strange career. Only those who have known suffering and anxiety can fully understand the drama and the beauty of this life.

Throughout his existence Leonardo had carried on simultaneously, and almost without a break, his work as an artist, as a scientist, as an engineer. Such a diversity of gifts was not as unusual in his day as it would be now. Paolo Uccello, Leo B. Alberti, Piero dei Franceschi, even Verrocchio himself, had shown more than a casual interest in scientific matters, such as perspective and anatomy, but Leonardo towers far above them. The excellence of his endowment is far more amazing than its complexity. His curiosity was universal to such a degree that to write a complete study of his genius amounts to writing a real encyclopædia of fifteenth-century science and technology. From his earliest age he had given proofs of this insatiable thirst for knowledge. He could take nothing for granted. Everything that he saw, either in the fields or on the moving surface of a river, or in the sky, or in the bottega of his master, or in the workshops of Florence, raised a new problem in his mind. Most of the time neither man nor book could give an answer to his question, and his mind kept working on it and remained restless until he had devised one himself. This means, of course, that there was no rest for him until the end. In a few cases, however, a satisfactory answer suggested itself, and so a whole system of knowledge was slowly unfolding in him.

His apprenticeship in Verrocchio's studio must have greatly fostered his inquiries in the theory of perspective, the art of light and shade, and the physiology of vision; the preparation of colors and varnishes must have turned his thoughts to chemistry, while the routine of his work woke up naturally enough his interest in anatomy. He could not long be satisfied by the study of the so-called artistic anatomy, which deals only with the exterior muscles. For one thing, the study of the movements of the human figure, which he tried to express in his drawings, raised innumerable questions: how were they possible, what kept the

human machine moving and how did it work? . . . It is easy to imagine how he was irresistibly driven step by step to investigate every anatomical and physiological problem. There are in the King's library at Windsor hundreds of drawings of his which prove that he made a thorough analysis of practically all the organs. Indeed, he had dissected quite a number of bodies, including that of a gravid woman, and his minute and comprehensive sketches are the first anatomical drawings worthy of the name. Many of these sketches are devoted to the comparison of human anatomy with the anatomy of animals, the monkey or the horse for instance; or else he will compare similar parts of various animals, say, the eyes or a leg and a wing. Other sketches relate to pathological anatomy: the hardening of the arteries; tuberculous lesions of the lungs; a very searching study of the symptoms of senility. On the other hand his activity as a practical engineer led him to study, or we might almost say to found, geology: he set to wonder at the various layers of sand and clay which the cutting of a canal did not fail to display; he tried to explain the fossils which he found embedded in the rocks and his explanations were substantially correct. Moreover, he clearly perceived the extreme slowness of most geological transformations, and figured that the alluvial deposits of the river Po were two hundred thousand years old. He well understood the geological action of water and its meteorological cycle. His work as a sculptor, or as a military engineer (for instance, when he had to supervise the casting of bombards), caused him to study metallurgy, particularly the smelting and casting of bronze, the rolling, drawing, planing, and drilling of iron. On all these subjects he has left elaborate instructions and drawings. He undertook in various parts of northern Italy a vast amount of hydraulic work: digging of canals, for which he devised a whole range of excavating machines and tools; building of sluices; establishment of water wheels and pipes, and his study of hydrodynamics was so continuous that notes referring to it are found in all his manuscripts. He also studied the tides, but did not understand them.

In fact, it is impossible to give even a superficial account of all his scientific and technical investigations, and the reader must forgive me if the magnitude of the subject obliges me to limit myself to a sort of catalogue, for the adequate development of any single point would take many a page. Leonardo's manuscripts contain a great number of architectural drawings, sketches of churches and other buildings, but also more technical matters; he studied the proportion of arches, the construction of bridges and staircases; how to repair fissures in walls; how to lift up and move houses and churches. There is also much of what we would call town-planning; the plague of Milan in 1484 likely was his great opportunity in this field, and he thought of various schemes to improve public sanitation and convenience, including a two-level system of streets. Botany repeatedly fixed his attention and we find many notes on the life of plants, the mathematical distribution of leaves on a stem, also beautiful and characteristic drawings of various species. A great deal of the work undertaken for his employers was of course connected with military engineering: hundreds of notes and sketches on all sorts of arms and armor, on all imaginable offensive and defensive appliances; of course, many plans for fortifications and strongholds (how to attack them and how to defend them); portable bridges; mining and countermining; *tanks;* various devices for the use of liquid fire, or of poisoning and asphyxiating fumes. He adds occasional notes on military and naval operations. He had even thought of some kind of submarine apparatus, by means of which ships could be sunk, but the dastardliness of the idea had horrified and stopped him.

No field, however, could offer a fuller scope to his prodigious versatility and ingenuity than the one of practical mechanics. A very intense industrial development had taken place in Tuscany and Lombardy for centuries before Leonardo's birth; the prosperity of their workshops was greater than ever; there was a continuous demand for inventions of all kinds, and no environment was more proper to enhance his mechanical genius. Leonardo was a born mechanic. He had

a deep understanding of the elementary parts of which any machine, however complicated, is made up, and his keen sense of proportions stood him in good stead when he started to build it. He devised machines for almost every purpose which could be thought of in his day. I quote a few examples at random: various types of lathes; machines to shear cloth; automatic file-cutting machines; sprocket wheels and chains for power transmission; machines to saw marble, to raise water, to grind plane and concave mirrors, to dive under water, to lift up, to heat, to light; paddle-wheels to move boats. And mind you, Leonardo was never satisfied with the applications alone, he wanted to understand as thoroughly as possible the principles underlying them. He clearly saw that practice and theory are twin sisters who must develop together, that theory without practice is senseless, and practice without theory hopeless. So it was not enough for him to hit upon a contrivance which answered his purpose; he wanted to know the cause of his success, or, as the case may be, of his failure. That is how we find in his papers the earliest systematic researches on such subjects as the stability of structures, the strength of materials, also on friction which he tried in various ways to overcome. That is not all: he seems to have grasped the principle of automaticity—that a machine is so much the more efficient, that it is more continuous and more independent of human attention. He had even conceived, in a special case, a judicious saving of human labor, that is what we now call "scientific management." . . .

His greatest achievement in the field of mechanics, however, and one which would be sufficient in itself to prove his extraordinary genius, is his exhaustive study of the problem of flying. It is complete, in so far that it would have been impossible to go further at his time, or indeed at any time until the progress of the automobile industry had developed a suitable motor. These investigations which occupied Leonardo throughout his life, were of two kinds. First, a study of the natural flying of birds and bats, and of the structure and function of their wings. He most clearly saw that the bird extracts from the air the recoil and the resistance which is necessary to elevate and carry itself forward. He observed how birds took advantage of the wind and how they used their wings, tails, and heads as propellers, balancers and rudders. In the second place, a mechanical study of various kinds of artificial wings, and of diverse apparatus by means of which a man might move them, using for instance the potential energy of springs, and others which he would employ to equilibrate his machine and steer its course.

It is necessary to insist that most of these drawings and notes of Leonardo are not idle schemes, or vague and easy suggestions such as we find, for instance, in the writings of Roger Bacon; but, on the contrary, very definite and clear ideas which could have been patented, if such a thing as a patent office had already existed! Moreover, a number of these drawings are so elaborate, giving us general views of the whole machine from different directions, and minute sketches of every single piece and of every detail of importance—that it would be easy enough to reconstruct it. In many cases, however, that is not even necessary, since these machines were actually constructed and used, some of them almost to our own time.

To better visualize the activity of his mind, I would now suggest to take at random a few years of his life, and to watch him at work. We might take, for instance, those years of divine inspiration when he was painting the "Last Supper" in the refectory of Santa Maria delle Grazie, that is about 1494–8. Do you suppose that this vast undertaking claimed the whole of his attention?

During these few years we see him act professionally as a pageant master, a decorator, an architect, an hydraulic engineer. His friend, Fra Luca Pacioli, the mathematician, tells us that by 1498 Leonardo "had completed with the greatest care his book on painting and on the movements of the human figure." We also know that before 1499, he had painted the portraits of Cecilia Gallerani and of Lucrezia Crivelli. Besides, his note-books of that period show that he

was interested in a great variety of other subjects, chief among them hydraulics, flying, optics, dynamics, zoology, and the construction of various machines. He was also making a study of his own language, and preparing a sort of Italian dictionary. No wonder that the prior of Santa Maria complained of his slowness! It so happened that during these four years he did not do much anatomical work, but during almost any other period he would have been carrying on some dissecting. Corpses were always hard to get, and I suppose that when he could get hold of one he made the most of it, working day and night as fast as he could. Then, as a change, he would go out into the fields and gaze at the stars, or at the earthshine which he could see inside the crescent of the moon; or else, if it were daytime, he would pick up fossils or marvel at the regularities of plant structure, or watch chicks breaking their shells. . . . Was it not uncanny? Fortunate was he to be born at a time of relative toleration. If he had appeared a century later, when religious fanaticism had been awakened, be sure this immoderate curiosity would have led him straight to the stake.

But remarkable as Leonardo's universality is, his earnestness and thoroughness are even more so. There is not a bit of dilettanteism in him. If a problem has once arrested his attention, he will come back to it year after year. In some cases, we can actually follow his experiments and the hesitations and slow progress of his mind for a period of more than twenty-five years. That is not the least fascinating side of his notes; as he wrote them for his own private use, it is almost as if we heard him think, as if we were admitted to the secret laboratory where his discoveries were slowly maturing. Such an opportunity is unique in the history of science.

Just try to realize what it means: Here we have a man of considerable mother-wit, but unlearned, unsophisticated, who had to take up every question at the very beginning, like a child. Leonardo opened his eyes and looked straight upon the world. There were no books between nature and him; he was untrammelled by learning, prejudice, or convention. He just asked himself questions, made experiments and used his common sense. The world was one to him, and so was science, and so was art. But he did not lose himself in sterile contemplation, or in verbal generalities. He tried to solve patiently each little problem separately. He saw that the only fruitful way of doing that is first to state the problem as clearly as possible, then to isolate it, to make the necessary experiments and to discuss them. Experiment is always at the bottom; mathematics, that is, reason, at the end. In short, the method of inductive philosophy which Francis Bacon was to explain so well a century and a half later, Leonardo actually practised.

This is, indeed, his greatest contribution: his method. He deeply realized that if we are to know something of this world, we can know it only by patient observation and tireless experiment. His note-books are just full of experiments and experimental suggestions, "Try this . . . do that . . ." and we find also whole series of experiments, wherein one condition and then another are gradually varied. Now, that may seem of little account, yet it is everything. We can count on our fingers the men who devised real experiments before Leonardo, and these experiments are very few in number and very simple.

But perhaps the best way to show how far he stood on the road to progress, is to consider his attitude in regard to the many superstitions to which even the noblest and most emancipated minds of his day paid homage, and which were to sway Europe for more than two centuries after Leonardo's death. Just remember that in 1484, the Pope Boniface VIII had sown the seed of the witch mania, and that this terrible madness was slowly incubating at the time of which we are speaking. Now, Leonardo's contempt for astrologers and alchemists was most outspoken and unconditional. He met the spiritists of his age, as we do those of to-day, by simply placing the burden of proof on their shoulders. It is true, for all these matters, his Florentine ancestry stood him in good stead. Petrarca had already shown how Florentine common sense disposed of them; but Petrarca, man of letters, would not have dared to treat the believers in ghosts, the medical

quacks, the necromancers, the searchers for gold and for perpetual motion as one bunch of impostors. And that is what Leonardo did repeatedly and most decidedly. Oh! how they must have liked him!

I must insist on this point: it is his ignorance which saved Leonardo. I do not mean to say that he was entirely unlearned, but he was sufficiently unlearned to be untrammelled. However much he may have read in his mature years, I am convinced that the literary studies of his youth were very poor. No teachers had time to mould his mind and to pervert his judgment. The good workman Verrocchio was perhaps his first philosopher, nature herself his real teacher. He was bred upon the experiments of the studio and of real life, not upon the artificialities of a mediæval library. He read more, later in life, but even then his readings, I think, were never exhaustive. He was far too original, too impatient. If he began to read some idea would soon cross his head, divert his attention, and the book would be abandoned. Anyhow, at that time his mind was already proof against the scholastic fallacies; he was able, so to say, to filter through his own experience whatever mediæval philosophy reached him either in print or by word of mouth.

Neither do I mean to imply that all the schoolmen were dunces. Far from that, not a few were men of amazing genius, but their point of view was never free from prejudice; it was always the theological or legal point of view; they were always like lawyers pleading a cause; they were constitutionally unable to investigate a problem without reservation and without fear. Moreover, they were so cocksure, so dogmatic. Their world was a limited, a closed system; had they not encompassed and exhausted it in their learned encyclopædias? In fact they knew everything except their own ignorance.

Now the fact that Leonardo had been protected against them by his innocence is of course insufficient to account for his genius. Innocence is but a negative quality. Leonardo came to be what he was because he combined in himself a keen and candid intelligence with great technical experience and unusual craftsmanship. That is the very key to the mystery. Maybe that if he had been simply a theoretical physicist, as were many of the schoolmen (their interest in astronomy and physics was intense), he would not have engaged in so many experiments. But as an engineer, a mechanic, a craftsman, he was experimenting all the while; he could not help it. If he had not experimented on nature, nature would have experimented on him; it was only a choice between offensive and defensive experimenting. Anyhow, whether he chose to take the initiative or not, these experiments were the fountainhead of his genius. To be sure, he had also a genuine interest in science, and the practical problems which he encountered progressively allured him to study it for its own sake, but that took time: once more the craftsman was the father of the scientist.

I would not have the reader believe that everything was wrong and dark in the Middle Ages. This childish view has long been exploded. The most wonderful craftsmanship inspired by noble ideals was its great redeeming feature, but unfortunately it had never been applied outside the realm of religion and of beauty. The love of truth did not exalt mediæval craftsmen, and it is unlikely that the thought of placing his art at the service of truth ever occurred to any of them.

Now, one does not understand the Renaissance if one fails to see that the revolution—I almost wrote, the miracle—which happened at that time was essentially the application of this spirit of craftsmanship and experiment to the quest of truth, its sudden extension from the realm of beauty to the realm of science. That is exactly what Leonardo and his fellow investigators did. And there and then modern science was born, but unfortunately Leonardo remained silent, and its prophets only came a century later. . . .

Man has not yet found a better way to be truly original than to go back to nature and to disclose one of her secrets. The Renaissance would not have been a real revolution, if it had been simply a going back to the ancients; it was far more, it was a return to nature. The

world, hitherto closed in and pretty as the garden of a beguinage, suddenly opened into infinity. It gradually occurred to the people—to only very few at first—that the world was not closed and limited, but unlimited, living, forever becoming. The whole perspective of knowledge was upset, and as a natural consequence all moral and social values were transmuted. The humanists had paved the way, for the discovery of the classics had sharpened the critical sense of man, but the revolution itself could only be accomplished by the experimental philosophers. It is clear that the spirit of individuality, which is so often claimed to be the chief characteristic of this movement, is only one aspect of the experimental attitude.

It may seem strange that this technical basis of the Renaissance has been constantly overlooked, but that is simply due to the fact that our historians are literary people, having no interest whatever in craftsmanship. Even in art it is the idea and the ultimate result, not the process and the technique which engross their attention. Many of them look upon any kind of handicraft as something menial. Of course, this narrow view makes it impossible for them to grasp the essential unity of thought and technique, or of science and art. The scope of abstract thinking is very limited; if it be not constantly rejuvenated by contact with nature our mind soon turns in a circle and works in a vacuum. The fundamental vice of the schoolmen was their inability to avow that, however rich experimental premises may be, their contents are limited;—and there is no magic by means of which it is possible to extract from them more than they contain.

The fact that Leonardo's main contribution is the introduction, not of a system, but rather of a method, a point of view, caused his influence to be restricted to the few people who were not impervious to it. Of course, at almost any period of the past there have been some people —only a very few—who did not need any initiation to understand the experimental point of view, because their souls were naturally oriented in the right way. These men form, so to say, one great intellectual family: Aristotle, Archimedes, Ptolemy, Roger Bacon, Leonardo, Stevin, Gilbert, Galileo, Huygens, Newton. . . . They hardly need any incentive; they are all right anyhow. However, Leonardo's influence was even more restricted than theirs, because he could never prevail upon himself to publish the results of his experiments and meditations. His notes show that he could occasionally write in a terse language and with a felicity of expression which would be a credit to any writer; but somehow he lacked that particular kind of moral energy which is necessary for a long composition, or he was perhaps inhibited, as so many scientists are, by his exacting ideal of accuracy.

All that we know of Leonardo's scientific activities is patiently dug out of his manuscripts. About 5,800 pages are extant, of which 1,150 are still practically unexplored. He was left-handed and wrote left-handedly, that is in mirror-writing: his writing is like the image of ours in a mirror. It is a clear hand, but the disorder of the text is such that the reading is very painful. Leonardo jumps from one subject to another; the same page may contain remarks on dynamics, on astronomy, an anatomical sketch, and perhaps a draft and calculations for a machine. Now, it is clear that to thoroughly understand his thoughts on any subject, a study, however exhaustive, of one manuscript is insufficient; it is necessary to follow him through all the manuscripts. Incredible as it may seem, that has not yet been done! After four centuries we do not yet know the text of Leonardo in the sense that we know the text of Shakespeare or of Dante; such knowledge will only become accessible when all the manuscripts have been published, and their contents classified in a systematic order. In other words, we shall only know Leonardo when the labor of composition and editing, which he left undone, has been accomplished.

If I may be permitted to say a few words of it, the task in which I am engaged is precisely the establishment of a standard text of Leonardo's writings, and furthermore the elaborate study of the origin and the development of his thoughts. From what I have said above, it is sufficiently clear that this part of my task is nothing less than the preparation

of an encyclopædic survey of artistic, scientific, and technical thought at the height of the Italian Renaissance. To measure the size of this undertaking, it is enough to bring before one's mind the many scholarly lives which have been entirely spent, and well spent, in a similar endeavor with regard to Dante. Yet the study of Dante is in many ways far simpler. His scientific lore does not begin to compare with Leonardo's knowledge. The *Divina Commedia* is the sublime apotheosis of the Middle Ages; Leonardo's note-books are not simply an epitome of the past, but they contain to a large extent the seeds of the future. The world of Dante was the closed mediæval world; the world of Leonardo is already the unlimited world of modern man: the immense vision which it opens is not simply one of beauty, of implicit faith, and of corresponding hope; it is a vision of truth, truth in the making. It is perhaps less pleasant, less hopeful; it does not even try to please, nor to give hope; it just tries to show things as they are: it is far more mysterious, and incomparably greater.

I do not mean to say that Dante had not loved truth, but he had loved it like a bashful suitor, while Leonardo was a conquering hero. His was not a passive love, but a devouring passion, an indefatigable and self-denying quest, to which his life and personal happiness were entirely sacrificed. Some literary people who do not realize what this quest implies, have said that he was selfish. It is true, he took no interest in the petty and hopeless political struggles of his day; Savonarola's revival did hardly move him, and he had no more use for religious charlatanry than for scientific quackery. He would be a poor man, however, who would not recognize at once in his aphorisms a genuine religious feeling, that is, a deep sense of brotherhood and unity. His generosity, his spirit of detachment, even his melancholy, are unmistakable signs of true nobility. He makes me often think of Pascal. He was very lonely, of course, from his own choice, because he needed time and quietness, but also because, being so utterly different, it is easy to conceive that many did not like him. I find it hard to believe that he was very genial, in spite of what Vasari says. Being surrounded by people whose moral standards were rather low or, if these were higher, who were apt to lose their balance and to become hysterical because of their lack of knowledge, Leonardo's solitude could but increase, and to protect his equanimity he was obliged to envelop himself in a triple veil of patience, kindness, and irony.

Leonardo's greatest contribution was his method, his attitude; his masterpiece was his life. I have heard people foolishly regret that his insatiable curiosity had diverted him from his work as a painter. In the spiritual sphere it is only quality that matters. If he had painted more and roamed less along untrodden paths, his paintings perhaps would not have taught us more than do those of his Milanese disciples. While, even as they stand now, scarce and partly destroyed, they deliver to us a message which is so uncompromisingly high that even to-day but few understand it. Let us listen to it; it is worth while. This message is as pertinent and as urgent to-day as it was more than four hundred years ago. And should it not have become more convincing because of all the discoveries which have been made in the meanwhile? Do I dream, or do I actually hear, across these four centuries, Leonardo whisper: "To know is to love. Our first duty is to know. These people who always call me a painter do annoy me. Of course, I was a painter, but I was also an engineer, a mechanic. My life was one long struggle with nature, to unravel her secrets and tame her wild forces to the purpose of man. They laughed at me because I was unlettered and slow of speech. Was I? Let me tell you: a literary education is no education. All the classics of the past cannot make men. Experience does, life does. They are rotten with learning and understand nothing. Why do they lie to themselves? How can they keep on living in the shade of knowledge, without coming out in the sun? How can they be satisfied with so little—when there is so much to be known, so much to be admired? . . . They love beauty, so they say—but beauty without truth is nothing but poison. Why do they not interrogate nature? Must we not first understand the laws of nature, and then only the laws and the conventionalities of men?

Should we not give more importance to that which is most permanent? The study of nature is the substance of education—the rest is only the ornament. Study it with your brains and with your hands. Do not be afraid to touch her. Those who fear to experiment with their hands will never know anything. We must all be craftsmen of some kind. Honest craftsmanship is the hope of the world. . . ."

And that is not all, because Leonardo's message is a very complex one. He has also something to say of the scientists, or rather of these overtrained and uneducated specialists, these Pharisees of science, almost as inarticulate as fishes: "What do these people know anyhow? They are trying to find the truth, so they say. But why don't they try to be human? Why are they so pale and so peevish? Why do they stand outside like beggars? How is it that all their science has failed to enlighten them? Why are they so afraid of beauty? Is knowledge without beauty and without love worth anything? . . ."

We must try to reconcile idealism and knowledge, science and art, truth and beauty. The ability of every man to do so is the real measure of his education. In the last analysis, that is what Leonardo tells us, and it is also the message of the New Humanism.

THE CHARM OF OLD NEW ORLEANS

By Edward Larocque Tinker

ILLUSTRATIONS FROM PHOTOGRAPHS BY THE AUTHOR

CHARLES MERYON, with an affectionate etching-needle, working on a copper plate bitten by the concentrated essence of his devotion and admiration for his subject, has left us etchings which preserve the glorious memories of a wonderful old Paris, already almost passed. Pennell first heralded the poetry of Pittsburg, and the artistic possibilities of the New York sky-scraper. For the aspiring young artist, either etcher or painter, there remains close at home a new field just as fertile; so fertile in fact that he who succeeds in adequately translating the fascination and charm of old New Orleans, before it has been lost, will build for himself a monument which will live long after his death to make Americans proud, not only of their artists, but also of those old French and Spanish ancestors who builded that city.

Latin taste has moulded the form and decreed the decorations of all the old buildings of the "Vieux Carré," or old part of the city. In some of the streets you almost imagine yourself in Seville, Naples, old Paris, or Habana. The Spanish settlers imposed on the architecture their feeling that a house, like a family, should present to the world a quiet impassive front, with just a glimpse through a well-balanced archway of a patio filled with fig-trees and flowers, where the real family life was lived. But the fine hand of our French ancestors is equally apparent. With their greater love of the graceful, they have added balconies with wrought-iron railings, hand-forged by negro slaves, from wonderful designs, carried in their master's hearts from their beloved France. The Spanish contributed their love of bright colors, and for a hundred years or more, these houses have been painted in alternating coats of pink, soft green, orange, blue, red, each coat fading soon in the severe sunlight, and being overlaid with some new color, until now, due to the continued assaults of the elements, many colors show through, giving a vividly varied but harmonious tone to the old walls that would make a painter's left hand itch for his palette and his right for a brush.

Then there are the market-places from whose cool, dark depths you can look out into the brilliant sunshine at the Rembrandt-lighted figures of the hucksters in picturesque groups near the curb, semi-