

**The Notebooks of Leonardo Da Vinci, Complete**

**By**

**Leonardo Da Vinci**

## PREFACE.

A singular fatality has ruled the destiny of nearly all the most famous of Leonardo da Vinci's works. Two of the three most important were never completed, obstacles having arisen during his life-time, which obliged him to leave them unfinished; namely the Sforza Monument and the Wall-painting of the Battle of Anghiari, while the third--the picture of the Last Supper at Milan--has suffered irremediable injury from decay and the repeated restorations to which it was recklessly subjected during the XVIIth and XVIIIth centuries. Nevertheless, no other picture of the Renaissance has become so wellknown and popular through copies of every description.

Vasari says, and rightly, in his Life of Leonardo, "that he laboured much more by his word than in fact or by deed", and the biographer evidently had in his mind the numerous works in Manuscript which have been preserved to this day. To us, now, it seems almost inexplicable that these valuable and interesting original texts should have remained so long unpublished, and indeed forgotten. It is certain that during the XVIth and XVIIth centuries their exceptional value was highly appreciated. This is proved not merely by the prices which they commanded, but also by the exceptional

interest which has been attached to the change of ownership of merely a few pages of Manuscript.

That, notwithstanding this eagerness to possess the Manuscripts, their contents remained a mystery, can only be accounted for by the many and great difficulties attending the task of deciphering them. The handwriting is so peculiar that it requires considerable practice to read even a few detached phrases, much more to solve with any certainty the numerous difficulties of alternative readings, and to master the sense as a connected whole. Vasari observes with reference to Leonardos writing: "he wrote backwards, in rude characters, and with the left hand, so that any one who is not practised in reading them, cannot understand them". The aid of a mirror in reading reversed handwriting appears to me available only for a first experimental reading. Speaking from my own experience, the persistent use of it is too fatiguing and inconvenient to be practically advisable, considering the enormous mass of Manuscripts to be deciphered. And as, after all, Leonardo's handwriting runs backwards just as all Oriental character runs backwards--that is to say from right to left--the difficulty of reading direct from the writing is not insuperable. This obvious peculiarity in the writing is not, however, by any means the only obstacle in the way of mastering the text. Leonardo made use of an orthography peculiar to himself; he had a fashion of amalgamating several short words into one long one, or, again, he would quite arbitrarily divide a long word into two separate halves; added to this there is no punctuation

whatever to regulate the division and construction of the sentences, nor are there any accents--and the reader may imagine that such difficulties were almost sufficient to make the task seem a desperate one to a beginner. It is therefore not surprising that the good intentions of some of Leonardo's most reverent admirers should have failed.

Leonardo's literary labours in various departments both of Art and of Science were those essentially of an enquirer, hence the analytical method is that which he employs in arguing out his investigations and dissertations. The vast structure of his scientific theories is consequently built up of numerous separate researches, and it is much to be lamented that he should never have collated and arranged them. His love for detailed research--as it seems to me--was the reason that in almost all the Manuscripts, the different paragraphs appear to us to be in utter confusion; on one and the same page, observations on the most dissimilar subjects follow each other without any connection. A page, for instance, will begin with some principles of astronomy, or the motion of the earth; then come the laws of sound, and finally some precepts as to colour. Another page will begin with his investigations on the structure of the intestines, and end with philosophical remarks as to the relations of poetry to painting; and so forth.

Leonardo himself lamented this confusion, and for that reason I do not think that the publication of the texts in the order in which

they occur in the originals would at all fulfil his intentions. No reader could find his way through such a labyrinth; Leonardo himself could not have done it.

Added to this, more than half of the five thousand manuscript pages which now remain to us, are written on loose leaves, and at present arranged in a manner which has no justification beyond the fancy of the collector who first brought them together to make volumes of more or less extent. Nay, even in the volumes, the pages of which were numbered by Leonardo himself, their order, so far as the connection of the texts was concerned, was obviously a matter of indifference to him. The only point he seems to have kept in view, when first writing down his notes, was that each observation should be complete to the end on the page on which it was begun. The exceptions to this rule are extremely few, and it is certainly noteworthy that we find in such cases, in bound volumes with his numbered pages, the written observations: "turn over", "This is the continuation of the previous page", and the like. Is not this sufficient to prove that it was only in quite exceptional cases that the writer intended the consecutive pages to remain connected, when he should, at last, carry out the often planned arrangement of his writings?

What this final arrangement was to be, Leonardo has in most cases indicated with considerable completeness. In other cases this authoritative clue is wanting, but the difficulties arising from

this are not insuperable; for, as the subject of the separate paragraphs is always distinct and well defined in itself, it is quite possible to construct a well-planned whole, out of the scattered materials of his scientific system, and I may venture to state that I have devoted especial care and thought to the due execution of this responsible task.

The beginning of Leonardo's literary labours dates from about his thirty-seventh year, and he seems to have carried them on without any serious interruption till his death. Thus the Manuscripts that remain represent a period of about thirty years. Within this space of time his handwriting altered so little that it is impossible to judge from it of the date of any particular text. The exact dates, indeed, can only be assigned to certain note-books in which the year is incidentally indicated, and in which the order of the leaves has not been altered since Leonardo used them. The assistance these afford for a chronological arrangement of the Manuscripts is generally self evident. By this clue I have assigned to the original Manuscripts now scattered through England, Italy and France, the order of their production, as in many matters of detail it is highly important to be able to verify the time and place at which certain observations were made and registered. For this purpose the Bibliography of the Manuscripts given at the end of Vol. II, may be regarded as an Index, not far short of complete, of all Leonardo's literary works now extant. The consecutive numbers (from 1 to 1566) at the head of each passage in this work, indicate their logical

sequence with reference to the subjects; while the letters and figures to the left of each paragraph refer to the original Manuscript and number of the page, on which that particular passage is to be found. Thus the reader, by referring to the List of Manuscripts at the beginning of Volume I, and to the Bibliography at the end of Volume II, can, in every instance, easily ascertain, not merely the period to which the passage belongs, but also exactly where it stood in the original document. Thus, too, by following the sequence of the numbers in the Bibliographical index, the reader may reconstruct the original order of the Manuscripts and recombine the various texts to be found on the original sheets--so much of it, that is to say, as by its subject-matter came within the scope of this work. It may, however, be here observed that Leonardo's Manuscripts contain, besides the passages here printed, a great number of notes and dissertations on Mechanics, Physics, and some other subjects, many of which could only be satisfactorily dealt with by specialists. I have given as complete a review of these writings as seemed necessary in the Bibliographical notes.

In 1651, Raphael Trichet Dufresne, of Paris, published a selection from Leonardo's writings on painting, and this treatise became so popular that it has since been reprinted about two-and-twenty times, and in six different languages. But none of these editions were derived from the original texts, which were supposed to have been lost, but from early copies, in which Leonardo's text had been more or less mutilated, and which were all fragmentary. The oldest and on

the whole the best copy of Leonardo's essays and precepts on Painting is in the Vatican Library; this has been twice printed, first by Manzi, in 1817, and secondly by Ludwig, in 1882. Still, this ancient copy, and the published editions of it, contain much for which it would be rash to hold Leonardo responsible, and some portions--such as the very important rules for the proportions of the human figure--are wholly wanting; on the other hand they contain passages which, if they are genuine, cannot now be verified from any original Manuscript extant. These copies, at any rate neither give us the original order of the texts, as written by Leonardo, nor do they afford any substitute, by connecting them on a rational scheme; indeed, in their chaotic confusion they are anything rather than satisfactory reading. The fault, no doubt, rests with the compiler of the Vatican copy, which would seem to be the source whence all the published and extensively known texts were derived; for, instead of arranging the passages himself, he was satisfied with recording a suggestion for a final arrangement of them into eight distinct parts, without attempting to carry out his scheme. Under the mistaken idea that this plan of distribution might be that, not of the compiler, but of Leonardo himself, the various editors, down to the present day, have very injudiciously continued to adopt this order--or rather disorder.

I, like other enquirers, had given up the original Manuscript of the Trattato della Pittura for lost, till, in the beginning of 1880, I was enabled, by the liberality of Lord Ashburnham, to inspect his



Manuscripts, and was so happy as to discover among them the original text of the best-known portion of the Trattato in his magnificent library at Ashburnham Place. Though this discovery was of a fragment only--but a considerable fragment--inciting me to further search, it gave the key to the mystery which had so long enveloped the first origin of all the known copies of the Trattato. The extensive researches I was subsequently enabled to prosecute, and the results of which are combined in this work, were only rendered possible by the unrestricted permission granted me to investigate all the Manuscripts by Leonardo dispersed throughout Europe, and to reproduce the highly important original sketches they contain, by the process of "photogravure". Her Majesty the Queen graciously accorded me special permission to copy for publication the Manuscripts at the Royal Library at Windsor. The Commission Centrale Administrative de l'Institut de France, Paris, gave me, in the most liberal manner, in answer to an application from Sir Frederic Leighton, P. R. A., Corresponding member of the Institut, free permission to work for several months in their private collection at deciphering the Manuscripts preserved there. The same favour which Lord Ashburnham had already granted me was extended to me by the Earl of Leicester, the Marchese Trivulsi, and the Curators of the Ambrosian Library at Milan, by the Conte Manzoni at Rome and by other private owners of Manuscripts of Leonardo's; as also by the Directors of the Louvre at Paris; the Accademia at Venice; the Uffizi at Florence; the Royal Library at Turin; and the British Museum, and the South Kensington Museum. I am also greatly indebted

to the Librarians of these various collections for much assistance in my labours; and more particularly to Monsieur Louis Lalanne, of the Institut de France, the Abbate Ceriani, of the Ambrosian Library, Mr. Maude Thompson, Keeper of Manuscripts at the British Museum, Mr. Holmes, the Queens Librarian at Windsor, the Revd Vere Bayne, Librarian of Christ Church College at Oxford, and the Revd A. Napier, Librarian to the Earl of Leicester at Holkham Hall.

In correcting the Italian text for the press, I have had the advantage of valuable advice from the Commendatore Giov. Morelli, Senatore del Regno, and from Signor Gustavo Frizzoni, of Milan. The translation, under many difficulties, of the Italian text into English, is mainly due to Mrs. R. C. Bell; while the rendering of several of the most puzzling and important passages, particularly in the second half of Vol. I, I owe to the indefatigable interest taken in this work by Mr. E. J. Poynter R. A. Finally I must express my thanks to Mr. Alfred Marks, of Long Ditton, who has most kindly assisted me throughout in the revision of the proof sheets.

The notes and dissertations on the texts on Architecture in Vol. II I owe to my friend Baron Henri de Geymuller, of Paris.

I may further mention with regard to the illustrations, that the negatives for the production of the "photo-gravures" by Monsieur Dujardin of Paris were all taken direct from the originals.

It is scarcely necessary to add that most of the drawings here reproduced in facsimile have never been published before. As I am now, on the termination of a work of several years' duration, in a position to review the general tenour of Leonardos writings, I may perhaps be permitted to add a word as to my own estimate of the value of their contents. I have already shown that it is due to nothing but a fortuitous succession of unfortunate circumstances, that we should not, long since, have known Leonardo, not merely as a Painter, but as an Author, a Philosopher, and a Naturalist. There can be no doubt that in more than one department his principles and discoveries were infinitely more in accord with the teachings of modern science, than with the views of his contemporaries. For this reason his extraordinary gifts and merits are far more likely to be appreciated in our own time than they could have been during the preceding centuries. He has been unjustly accused of having squandered his powers, by beginning a variety of studies and then, having hardly begun, throwing them aside. The truth is that the labours of three centuries have hardly sufficed for the elucidation of some of the problems which occupied his mighty mind.

Alexander von Humboldt has borne witness that "he was the first to start on the road towards the point where all the impressions of our senses converge in the idea of the Unity of Nature" Nay, yet more may be said. The very words which are inscribed on the monument of Alexander von Humboldt himself, at Berlin, are perhaps the most appropriate in which we can sum up our estimate of Leonardo's

genius:

"Majestati naturae par ingenium."

LONDON, April 1883.

F. P. R.

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The author's intention to publish his MSS.

1.

How by a certain machine many may stay some time under water. And how and wherefore I do not describe my method of remaining under water and how long I can remain without eating. And I do not publish nor divulge these, by reason of the evil nature of men, who would use them for assassinations at the bottom of the sea by destroying ships, and sinking them, together with the men in them. Nevertheless I will impart others, which are not dangerous because the mouth of the tube through which you breathe is above the water, supported on air sacks or cork.

[Footnote: The leaf on which this passage is written, is headed with the words *Casi 39*, and most of these cases begin with the word 'Come', like the two here given, which are the 26th and 27th. 7. *Sughero*. In the *Codex Antlanticus 377a; 1170a* there is a sketch, drawn with the pen, representing a man with a tube in his mouth, and at the farther end of the tube a disk. By the tube the word 'Channa' is written, and by the disk the word 'sughero'.]

The preparation of the MSS. for publication.

2.

When you put together the science of the motions of water, remember to include under each proposition its application and use, in order that this science may not be useless.--

[Footnote: A comparatively small portion of Leonardo's notes on water-power was published at Bologna in 1828, under the title: "Del moto e misura dell'Acqua, di L. da Vinci".]

Admonition to readers.

3.

Let no man who is not a Mathematician read the elements of my work.

The disorder in the MSS.

4.

Begun at Florence, in the house of Piero di Braccio Martelli, on the 22nd day of March 1508. And this is to be a collection without order, taken from many papers which I have copied here, hoping to arrange them later each in its place, according to the subjects of which they may treat. But I believe that before I am at the end of this [task] I shall have to repeat the same things several times; for which, O reader! do not blame me, for the subjects are many and memory cannot retain them [all] and say: 'I will not write this because I wrote it before.' And if I wished to avoid falling into this fault, it would be necessary in every case when I wanted to copy [a passage] that, not to repeat myself, I should read over all that had gone before; and all the more since the intervals are long

between one time of writing and the next.

[Footnote: 1. In the history of Florence in the early part of the XVIth century Piero di Braccio Martelli is frequently mentioned as Commissario della Signoria. He was famous for his learning and at his death left four books on Mathematics ready for the press; comp. LITTA, Famiglie celebri Italiane, Famiglia Martelli di Firenze.--In the Official Catalogue of MSS. in the Brit. Mus., New Series Vol. I., where this passage is printed, Barto has been wrongly given for Braccio.

2. addi 22 di marzo 1508. The Christian era was computed in Florence at that time from the Incarnation (Lady day, March 25th). Hence this should be 1509 by our reckoning.

3. raccolto tratto di molte carte le quali io ho qui copiate. We must suppose that Leonardo means that he has copied out his own MSS. and not those of others. The first thirteen leaves of the MS. in the Brit. Mus. are a fair copy of some notes on physics.]

Suggestions for the arrangement of MSS treating of particular subjects.(5-8).

5.

Of digging a canal. Put this in the Book of useful inventions and in



proving them bring forward the propositions already proved. And this is the proper order; since if you wished to show the usefulness of any plan you would be obliged again to devise new machines to prove its utility and thus would confuse the order of the forty Books and also the order of the diagrams; that is to say you would have to mix up practice with theory, which would produce a confused and incoherent work.

6.

I am not to blame for putting forward, in the course of my work on science, any general rule derived from a previous conclusion.

7.

The Book of the science of Mechanics must precede the Book of useful inventions.--Have your books on anatomy bound! [Footnote: 4. The numerous notes on anatomy written on loose leaves and now in the Royal collection at Windsor can best be classified in four Books, corresponding to the different character and size of the paper. When Leonardo speaks of 'li tua libri di notomia', he probably means the MSS. which still exist; if this hypothesis is correct the present condition of these leaves might seem to prove that he only carried out his purpose with one of the Books on anatomy. A borrowed book on Anatomy is mentioned in F.O.]

8.

The order of your book must proceed on this plan: first simple beams, then (those) supported from below, then suspended in part, then wholly [suspended]. Then beams as supporting other weights [Footnote: 4. Leonardo's notes on Mechanics are extraordinarily numerous; but, for the reasons assigned in my introduction, they have not been included in the present work.].

General introductions to the book on Painting (9-13).

9.

INTRODUCTION.

Seeing that I can find no subject specially useful or pleasing--since the men who have come before me have taken for their own every useful or necessary theme--I must do like one who, being poor, comes last to the fair, and can find no other way of providing himself than by taking all the things already seen by other buyers, and not taken but refused by reason of their lesser value. I, then, will load my humble pack with this despised and rejected merchandise, the refuse of so many buyers; and will go about to distribute it, not indeed in great cities, but in the poorer towns, taking such a price as the wares I offer may be worth. [Footnote: It need hardly be pointed out that there is in this 'Proemio' a covert

irony. In the second and third prefaces, Leonardo characterises his rivals and opponents more closely. His protest is directed against Neo-latinism as professed by most of the humanists of his time; its futility is now no longer questioned.]

10.

#### INTRODUCTION.

I know that many will call this useless work [Footnote: 3. questa essere opera inutile. By opera we must here understand libro di pittura and particularly the treatise on Perspective.]; and they will be those of whom Demetrius [Footnote: 4. Demetrio. "With regard to the passage attributed to Demetrius", Dr. H. MÜLLER STRÜBING writes, "I know not what to make of it. It is certainly not Demetrius Phalereus that is meant and it can hardly be Demetrius Poliorcetes. Who then can it be--for the name is a very common one? It may be a clerical error for Demades and the maxim is quite in the spirit of his writings I have not however been able to find any corresponding passage either in the 'Fragments' (C. MULLER, Orat. Att., II. 441) nor in the Supplements collected by DIETZ (Rhein. Mus., vol. 29, p. 108)."

The same passage occurs as a simple Memorandum in the MS. Tr. 57, apparently as a note for this 'Proemio' thus affording some data as to the time where these introductions were written.] declared

that he took no more account of the wind that came out their mouth in words, than of that they expelled from their lower parts: men who desire nothing but material riches and are absolutely devoid of that of wisdom, which is the food and the only true riches of the mind. For so much more worthy as the soul is than the body, so much more noble are the possessions of the soul than those of the body. And often, when I see one of these men take this work in his hand, I wonder that he does not put it to his nose, like a monkey, or ask me if it is something good to eat.

[Footnote: In the original, the Proemio di prospettiva cioè dell'uffitio dell'occhio (see No. 21) stands between this and the preceding one, No. 9.]

## INTRODUCTION.

I am fully concious that, not being a literary man, certain presumptuous persons will think that they may reasonably blame me; alleging that I am not a man of letters. Foolish folks! do they not know that I might retort as Marius did to the Roman Patricians [Footnote 21: Come Mario disse ai patriti Romani. "I am unable to find the words here attributed by Leonardo to Marius, either in Plutarch's Life of Marius or in the Apophthegmata (Moralia, p.202). Nor do they occur in the writings of Valerius Maximus (who frequently mentions Marius) nor in Velleius Paterculus (II, 11 to 43), Dio Cassius, Aulus Gellius, or Macrobius. Professor E.

MENDELSON of Dorpat, the editor of Herodian, assures me that no such passage is the found in that author" (communication from Dr. MULLER STRUBING). Leonardo evidently meant to allude to some well known incident in Roman history and the mention of Marius is the result probably of some confusion. We may perhaps read, for Marius, Menenius Agrippa, though in that case it is true we must alter Patriti to Plebei. The change is a serious one. but it would render the passage perfectly clear.] by saying: That they, who deck themselves out in the labours of others will not allow me my own. They will say that I, having no literary skill, cannot properly express that which I desire to treat of [Footnote 26: le mie cose .... che d'altra parola. This can hardly be reconciled with Mons. RAVAISSON'S estimate of L. da Vinci's learning. "Leonard de Vinci etait un admirateur et un disciple des anciens, aussi bien dans l'art que dans la science et il tenait a passer pour tel meme aux yeux de la posterite." Gaz. des Beaux arts. Oct. 1877.]; but they do not know that my subjects are to be dealt with by experience rather than by words [Footnote 28: See Footnote 26]; and [experience] has been the mistress of those who wrote well. And so, as mistress, I will cite her in all cases.

11.

Though I may not, like them, be able to quote other authors, I shall rely on that which is much greater and more worthy:--on experience, the mistress of their Masters. They go about puffed up and pompous,

dressed and decorated with [the fruits], not of their own labours, but of those of others. And they will not allow me my own. They will scorn me as an inventor; but how much more might they--who are not inventors but vaunters and declaimers of the works of others--be blamed.

#### INTRODUCTION.

And those men who are inventors and interpreters between Nature and Man, as compared with boasters and declaimers of the works of others, must be regarded and not otherwise esteemed than as the object in front of a mirror, when compared with its image seen in the mirror. For the first is something in itself, and the other nothingness.--Folks little indebted to Nature, since it is only by chance that they wear the human form and without it I might class them with the herds of beasts.

12.

Many will think they may reasonably blame me by alleging that my proofs are opposed to the authority of certain men held in the highest reverence by their inexperienced judgments; not considering that my works are the issue of pure and simple experience, who is the one true mistress. These rules are sufficient to enable you to know the true from the false--and this aids men to look only for things that are possible and with due moderation--and not to wrap

yourself in ignorance, a thing which can have no good result, so that in despair you would give yourself up to melancholy.

13.

Among all the studies of natural causes and reasons Light chiefly delights the beholder; and among the great features of Mathematics the certainty of its demonstrations is what preeminently (tends to) elevate the mind of the investigator. Perspective, therefore, must be preferred to all the discourses and systems of human learning. In this branch [of science] the beam of light is explained on those methods of demonstration which form the glory not so much of Mathematics as of Physics and are graced with the flowers of both [Footnote: 5. Such of Leonardo's notes on Optics or on Perspective as bear exclusively on Mathematics or Physics could not be included in the arrangement of the libro di pittura which is here presented to the reader. They are however but few.]. But its axioms being laid down at great length, I shall abridge them to a conclusive brevity, arranging them on the method both of their natural order and of mathematical demonstration; sometimes by deduction of the effects from the causes, and sometimes arguing the causes from the effects; adding also to my own conclusions some which, though not included in them, may nevertheless be inferred from them. Thus, if the Lord--who is the light of all things--vouchsafe to enlighten me, I will treat of Light; wherefore I will divide the present work into 3 Parts

[Footnote: 10. In the middle ages--for instance, by ROGER BACON, by

VITELLONE, with whose works Leonardo was certainly familiar, and by all the writers of the Renaissance Perspective and Optics were not regarded as distinct sciences. Perspective, indeed, is in its widest application the science of seeing. Although to Leonardo the two sciences were clearly separate, it is not so as to their names; thus we find axioms in Optics under the heading Perspective. According to this arrangement of the materials for the theoretical portion of the libro di pittura propositions in Perspective and in Optics stand side by side or occur alternately. Although this particular chapter deals only with Optics, it is not improbable that the words *partirò la presente opera in 3 parti* may refer to the same division into three sections which is spoken of in chapters 14 to 17.].

The plan of the book on Painting (14--17).

14.

#### ON THE THREE BRANCHES OF PERSPECTIVE.

There are three branches of perspective; the first deals with the reasons of the (apparent) diminution of objects as they recede from the eye, and is known as Diminishing Perspective.--The second contains the way in which colours vary as they recede from the eye. The third and last is concerned with the explanation of how the objects [in a picture] ought to be less finished in proportion as they are remote (and the names are as follows):



Linear Perspective. The Perspective of Colour. The Perspective of Disappearance.

[Footnote: 13. From the character of the handwriting I infer that this passage was written before the year 1490.]

15.

#### ON PAINTING AND PERSPECTIVE.

The divisions of Perspective are 3, as used in drawing; of these, the first includes the diminution in size of opaque objects; the second treats of the diminution and loss of outline in such opaque objects; the third, of the diminution and loss of colour at long distances.

[Footnote: The division is here the same as in the previous chapter No. 14, and this is worthy of note when we connect it with the fact that a space of about 20 years must have intervened between the writing of the two passages.]

16.

#### THE DISCOURSE ON PAINTING.

Perspective, as bearing on drawing, is divided into three principal sections; of which the first treats of the diminution in the size of bodies at different distances. The second part is that which treats of the diminution in colour in these objects. The third [deals with] the diminished distinctness of the forms and outlines displayed by the objects at various distances.

17.

#### ON THE SECTIONS OF [THE BOOK ON] PAINTING.

The first thing in painting is that the objects it represents should appear in relief, and that the grounds surrounding them at different distances shall appear within the vertical plane of the foreground of the picture by means of the 3 branches of Perspective, which are: the diminution in the distinctness of the forms of the objects, the diminution in their magnitude; and the diminution in their colour. And of these 3 classes of Perspective the first results from [the structure of] the eye, while the other two are caused by the atmosphere which intervenes between the eye and the objects seen by it. The second essential in painting is appropriate action and a due variety in the figures, so that the men may not all look like brothers, &c.

[Footnote: This and the two foregoing chapters must have been written in 1513 to 1516. They undoubtedly indicate the scheme which

Leonardo wished to carry out in arranging his researches on Perspective as applied to Painting. This is important because it is an evidence against the supposition of H. LUDWIG and others, that Leonardo had collected his principles of Perspective in one book so early as before 1500; a Book which, according to the hypothesis, must have been lost at a very early period, or destroyed possibly, by the French (!) in 1500 (see H. LUDWIG. L. da Vinci: Das Buch van der Malerei. Vienna 1882 III, 7 and 8).]

The use of the book on Painting.

18.

These rules are of use only in correcting the figures; since every man makes some mistakes in his first compositions and he who knows them not, cannot amend them. But you, knowing your errors, will correct your works and where you find mistakes amend them, and remember never to fall into them again. But if you try to apply these rules in composition you will never make an end, and will produce confusion in your works.

These rules will enable you to have a free and sound judgment; since good judgment is born of clear understanding, and a clear understanding comes of reasons derived from sound rules, and sound rules are the issue of sound experience--the common mother of all the sciences and arts. Hence, bearing in mind the precepts of my

rules, you will be able, merely by your amended judgment, to criticise and recognise every thing that is out of proportion in a work, whether in the perspective or in the figures or any thing else.

Necessity of theoretical knowledge (19. 20).

19.

OF THE MISTAKES MADE BY THOSE WHO PRACTISE WITHOUT KNOWLEDGE.

Those who are in love with practice without knowledge are like the sailor who gets into a ship without rudder or compass and who never can be certain whether he is going. Practice must always be founded on sound theory, and to this Perspective is the guide and the gateway; and without this nothing can be done well in the matter of drawing.

20.

The painter who draws merely by practice and by eye, without any reason, is like a mirror which copies every thing placed in front of it without being conscious of their existence.

The function of the eye (21-23).

21.

INTRODUCTION TO PERSPECTIVE:--THAT IS OF THE FUNCTION OF THE EYE.

Behold here O reader! a thing concerning which we cannot trust our forefathers, the ancients, who tried to define what the Soul and Life are--which are beyond proof, whereas those things, which can at any time be clearly known and proved by experience, remained for many ages unknown or falsely understood. The eye, whose function we so certainly know by experience, has, down to my own time, been defined by an infinite number of authors as one thing; but I find, by experience, that it is quite another. [Footnote 13: Compare the note to No. 70.]

[Footnote: In section 13 we already find it indicated that the study of Perspective and of Optics is to be based on that of the functions of the eye. Leonardo also refers to the science of the eye, in his astronomical researches, for instance in MS. F 25b 'Ordine del provare la terra essere una stella: Imprima difinisce l'occhio', &c. Compare also MS. E 15b and F 60b. The principles of astronomical perspective.]

22.

Here [in the eye] forms, here colours, here the character of every part of the universe are concentrated to a point; and that point is

so marvellous a thing ... Oh! marvellous, O stupendous Necessity--by thy laws thou dost compel every effect to be the direct result of its cause, by the shortest path. These [indeed] are miracles;...

In so small a space it can be reproduced and rearranged in its whole expanse. Describe in your anatomy what proportion there is between the diameters of all the images in the eye and the distance from them of the crystalline lens.

23.

OF THE 10 ATTRIBUTES OF THE EYE, ALL CONCERNED IN PAINTING.

Painting is concerned with all the 10 attributes of sight; which are:--Darkness, Light, Solidity and Colour, Form and Position, Distance and Propinquity, Motion and Rest. This little work of mine will be a tissue [of the studies] of these attributes, reminding the painter of the rules and methods by which he should use his art to imitate all the works of Nature which adorn the world.

24.

ON PAINTING.

Variability of the eye.

1st. The pupil of the eye contracts, in proportion to the increase of light which is reflected in it. 2nd. The pupil of the eye expands in proportion to the diminution in the day light, or any other light, that is reflected in it. 3rd. [Footnote: 8. The subject of this third proposition we find fully discussed in MS. G. 44a.]. The eye perceives and recognises the objects of its vision with greater intensity in proportion as the pupil is more widely dilated; and this can be proved by the case of nocturnal animals, such as cats, and certain birds--as the owl and others--in which the pupil varies in a high degree from large to small, &c., when in the dark or in the light. 4th. The eye [out of doors] in an illuminated atmosphere sees darkness behind the windows of houses which [nevertheless] are light. 5th. All colours when placed in the shade appear of an equal degree of darkness, among themselves. 6th. But all colours when placed in a full light, never vary from their true and essential hue.

25.

## OF THE EYE.

Focus of sight.

If the eye is required to look at an object placed too near to it, it cannot judge of it well--as happens to a man who tries to see the tip of his nose. Hence, as a general rule, Nature teaches us that an

object can never be seen perfectly unless the space between it and the eye is equal, at least, to the length of the face.

Differences of perception by one eye and by both eyes (26-29).

26.

OF THE EYE.

When both eyes direct the pyramid of sight to an object, that object becomes clearly seen and comprehended by the eyes.

27.

Objects seen by one and the same eye appear sometimes large, and sometimes small.

28.

The motion of a spectator who sees an object at rest often makes it seem as though the object at rest had acquired the motion of the moving body, while the moving person appears to be at rest.

ON PAINTING.

Objects in relief, when seen from a short distance with one eye,



look like a perfect picture. If you look with the eye a, b at the spot c, this point c will appear to be at d, f, and if you look at it with the eye g, h will appear to be at m. A picture can never contain in itself both aspects.

29.

Let the object in relief t be seen by both eyes; if you will look at the object with the right eye m, keeping the left eye n shut, the object will appear, or fill up the space, at a; and if you shut the right eye and open the left, the object (will occupy the) space b; and if you open both eyes, the object will no longer appear at a or b, but at e, r, f. Why will not a picture seen by both eyes produce the effect of relief, as [real] relief does when seen by both eyes; and why should a picture seen with one eye give the same effect of relief as real relief would under the same conditions of light and shade?

[Footnote: In the sketch, m is the left eye and n the right, while the text reverses this lettering. We must therefore suppose that the face in which the eyes m and n are placed is opposite to the spectator.]

30.

The comparative size of the image depends on the amount of light

(30-39).

The eye will hold and retain in itself the image of a luminous body better than that of a shaded object. The reason is that the eye is in itself perfectly dark and since two things that are alike cannot be distinguished, therefore the night, and other dark objects cannot be seen or recognised by the eye. Light is totally contrary and gives more distinctness, and counteracts and differs from the usual darkness of the eye, hence it leaves the impression of its image.

31.

Every object we see will appear larger at midnight than at midday, and larger in the morning than at midday.

This happens because the pupil of the eye is much smaller at midday than at any other time.

32.

The pupil which is largest will see objects the largest. This is evident when we look at luminous bodies, and particularly at those in the sky. When the eye comes out of darkness and suddenly looks up at these bodies, they at first appear larger and then diminish; and if you were to look at those bodies through a small opening, you would see them smaller still, because a smaller part of the pupil

would exercise its function.

[Footnote: 9. buso in the Lomb. dialect is the same as buco.]

33.

When the eye, coming out of darkness suddenly sees a luminous body, it will appear much larger at first sight than after long looking at it. The illuminated object will look larger and more brilliant, when seen with two eyes than with only one. A luminous object will appear smaller in size, when the eye sees it through a smaller opening. A luminous body of an oval form will appear rounder in proportion as it is farther from the eye.

34.

Why when the eye has just seen the light, does the half light look dark to it, and in the same way if it turns from the darkness the half light look very bright?

35.

ON PAINTING.

If the eye, when [out of doors] in the luminous atmosphere, sees a place in shadow, this will look very much darker than it really is.

This happens only because the eye when out in the air contracts the pupil in proportion as the atmosphere reflected in it is more luminous. And the more the pupil contracts, the less luminous do the objects appear that it sees. But as soon as the eye enters into a shady place the darkness of the shadow suddenly seems to diminish. This occurs because the greater the darkness into which the pupil goes the more its size increases, and this increase makes the darkness seem less.

[Footnote 14: La luce entrerà. Luce occurs here in the sense of pupil of the eye as in no 51: C. A. 84b; 245a; I--5; and in many other places.]

36.

#### ON PERSPECTIVE.

The eye which turns from a white object in the light of the sun and goes into a less fully lighted place will see everything as dark. And this happens either because the pupils of the eyes which have rested on this brilliantly lighted white object have contracted so much that, given at first a certain extent of surface, they will have lost more than  $3/4$  of their size; and, lacking in size, they are also deficient in [seeing] power. Though you might say to me: A little bird (then) coming down would see comparatively little, and from the smallness of his pupils the white might seem black! To this

I should reply that here we must have regard to the proportion of the mass of that portion of the brain which is given up to the sense of sight and to nothing else. Or--to return--this pupil in Man dilates and contracts according to the brightness or darkness of (surrounding) objects; and since it takes some time to dilate and contract, it cannot see immediately on going out of the light and into the shade, nor, in the same way, out of the shade into the light, and this very thing has already deceived me in painting an eye, and from that I learnt it.

37.

Experiment [showing] the dilatation and contraction of the pupil, from the motion of the sun and other luminaries. In proportion as the sky is darker the stars appear of larger size, and if you were to light up the medium these stars would look smaller; and this difference arises solely from the pupil which dilates and contracts with the amount of light in the medium which is interposed between the eye and the luminous body. Let the experiment be made, by placing a candle above your head at the same time that you look at a star; then gradually lower the candle till it is on a level with the ray that comes from the star to the eye, and then you will see the star diminish so much that you will almost lose sight of it.

[Footnote: No reference is made in the text to the letters on the accompanying diagram.]

38.

The pupil of the eye, in the open air, changes in size with every degree of motion from the sun; and at every degree of its changes one and the same object seen by it will appear of a different size; although most frequently the relative scale of surrounding objects does not allow us to detect these variations in any single object we may look at.

39.

The eye--which sees all objects reversed--retains the images for some time. This conclusion is proved by the results; because, the eye having gazed at light retains some impression of it. After looking (at it) there remain in the eye images of intense brightness, that make any less brilliant spot seem dark until the eye has lost the last trace of the impression of the stronger light.

II.

Linear Perspective.

We see clearly from the concluding sentence of section 49, where the author directly addresses the painter, that he must certainly have intended to include the elements of mathematics in his Book on the

art of Painting. They are therefore here placed at the beginning. In section 50 the theory of the "Pyramid of Sight" is distinctly and expressly put forward as the fundamental principle of linear perspective, and sections 52 to 57 treat of it fully. This theory of sight can scarcely be traced to any author of antiquity. Such passages as occur in Euclid for instance, may, it is true, have proved suggestive to the painters of the Renaissance, but it would be rash to say any thing decisive on this point.

Leon Battista Alberti treats of the "Pyramid of Sight" at some length in his first Book of Painting; but his explanation differs widely from Leonardo's in the details. Leonardo, like Alberti, may have borrowed the broad lines of his theory from some views commonly accepted among painters at the time; but he certainly worked out its application in a perfectly original manner.

The axioms as to the perception of the pyramid of rays are followed by explanations of its origin, and proofs of its universal application (58--69). The author recurs to the subject with endless variations; it is evidently of fundamental importance in his artistic theory and practice. It is unnecessary to discuss how far this theory has any scientific value at the present day; so much as this, at any rate, seems certain: that from the artist's point of view it may still claim to be of immense practical utility.

According to Leonardo, on one hand, the laws of perspective are an

inalienable condition of the existence of objects in space; on the other hand, by a natural law, the eye, whatever it sees and wherever it turns, is subjected to the perception of the pyramid of rays in the form of a minute target. Thus it sees objects in perspective independently of the will of the spectator, since the eye receives the images by means of the pyramid of rays "just as a magnet attracts iron".

In connection with this we have the function of the eye explained by the Camera obscura, and this is all the more interesting and important because no writer previous to Leonardo had treated of this subject (70--73). Subsequent passages, of no less special interest, betray his knowledge of refraction and of the inversion of the image in the camera and in the eye (74--82).

From the principle of the transmission of the image to the eye and to the camera obscura he deduces the means of producing an artificial construction of the pyramid of rays or--which is the same thing--of the image. The fundamental axioms as to the angle of sight and the vanishing point are thus presented in a manner which is as complete as it is simple and intelligible (86--89).

Leonardo distinguishes between simple and complex perspective (90, 91). The last sections treat of the apparent size of objects at various distances and of the way to estimate it (92--109).



General remarks on perspective (40-41).

40.

ON PAINTING.

Perspective is the best guide to the art of Painting.

[Footnote: 40. Compare 53, 2.]

41.

The art of perspective is of such a nature as to make what is flat appear in relief and what is in relief flat.

The elements of perspective--Of the Point (42-46).

42.

All the problems of perspective are made clear by the five terms of mathematicians, which are:--the point, the line, the angle, the superficies and the solid. The point is unique of its kind. And the point has neither height, breadth, length, nor depth, whence it is to be regarded as indivisible and as having no dimensions in space. The line is of three kinds, straight, curved and sinuous and it has neither breadth, height, nor depth. Hence it is indivisible,

excepting in its length, and its ends are two points. The angle is the junction of two lines in a point.

43.

A point is not part of a line.

44.

OF THE NATURAL POINT.

The smallest natural point is larger than all mathematical points, and this is proved because the natural point has continuity, and any thing that is continuous is infinitely divisible; but the mathematical point is indivisible because it has no size.

[Footnote: This definition was inserted by Leonardo on a MS. copy on parchment of the well-known "Trattato d'Architettura civile e militare" &c. by FRANCESCO DI GIORGIO; opposite a passage where the author says: 'In prima he da sapere che punto è quella parie della quale he nulla--Linia he luncheza senza àpieza; &c.]

45.

1, The superficies is a limitation of the body. 2, and the limitation of a body is no part of that body. 4, and the limitation