Combination of different colours in cast shadows.

272.

That which casts the shadow does not face it, because the shadows are produced by the light which causes and surrounds the shadows. The shadow caused by the light e, which is yellow, has a blue tinge, because the shadow of the body a is cast upon the pavement at b, where the blue light falls; and the shadow produced by the light d, which is blue, will be yellow at c, because the yellow light falls there and the surrounding background to these shadows b c will, besides its natural colour, assume a hue compounded of yellow and blue, because it is lighted by the yellow light and by the blue light both at once.

Shadows of various colours, as affected by the lights falling on them. That light which causes the shadow does not face it.

[Footnote: In the original diagram we find in the circle e "giallo" (yellow) and the cirle d "azurro" (blue) and also under the circle of shadow to the left "giallo" is written and under that to the right "azurro".

In the second diagram where four circles are placed in a row we find written, beginning at the left hand, "giallo" (yellow), "azurro" (blue), "verde" (green), "rosso" (red).]

The effect of colours in the camera obscura (273-274).

273.

The edges of a colour(ed object) transmitted through a small hole are more conspicuous than the central portions.

The edges of the images, of whatever colour, which are transmitted through a small aperture into a dark chamber will always be stronger than the middle portions.

274.

OF THE INTERSECTIONS OF THE IMAGES IN THE PUPIL OF THE EYE.

The intersections of the images as they enter the pupil do not mingle in confusion in the space where that intersection unites them; as is evident, since, if the rays of the sun pass through two panes of glass in close contact, of which one is blue and the other yellow, the rays, in penetrating them, do not become blue or yellow but a beautiful green. And the same thing would happen in the eye, if the images which were yellow or green should mingle where they [meet and] intersect as they enter the pupil. As this does not happen such a mingling does not exist.

OF THE NATURE OF THE RAYS COMPOSED OF THE IMAGES OF OBJECTS, AND OF

THEIR INTERSECTIONS.

The directness of the rays which transmit the forms and colours of the bodies whence they proceed does not tinge the air nor can they affect each other by contact where they intersect. They affect only the spot where they vanish and cease to exist, because that spot faces and is faced by the original source of these rays, and no other object, which surrounds that original source can be seen by the eye where these rays are cut off and destroyed, leaving there the spoil they have conveyed to it. And this is proved by the 4th [proposition], on the colour of bodies, which says: The surface of every opaque body is affected by the colour of surrounding objects; hence we may conclude that the spot which, by means of the rays which convey the image, faces--and is faced by the cause of the image, assumes the colour of that object.

On the colours of derived shadows (275. 276).

275.

ANY SHADOW CAST BY AN OPAQUE BODY SMALLER THAN THE LIGHT CAUSING THE

SHADOW WILL THROW A DERIVED SHADOW WHICH IS TINGED BY THE COLOUR OF

THE LIGHT.

Let n be the source of the shadow e f; it will assume its hue. Let o be the source of h e which will in the same way be tinged by its hue and so also the colour of v h will be affected by p which causes it; and the shadow of the triangle z k y will be affected by the colour of q, because it is produced by it. [7] In proportion as c d goes into a d, will n r s be darker than m; and the rest of the space will be shadowless [11]. f g is the highest light, because here the whole light of the window a d falls; and thus on the opaque body m e is in equally high light; z k y is a triangle which includes the deepest shadow, because the light a d cannot reach any part of it. x h is the 2nd grade of shadow, because it receives only 1/3 of the light from the window, that is c d. The third grade of shadow is h e, where two thirds of the light from the window is visible. The last grade of shadow is b d e f, because the highest grade of light from the window falls at f.

[Footnote: The diagram Pl. III, No. 1 belongs to this chapter as well as the text given in No. 148. Lines 7-11 (compare lines 8-12 of No. 148) which are written within the diagram, evidently apply to both sections and have therefore been inserted in both.]

276.

OF THE COLOURS OF SIMPLE DERIVED SHADOWS.

The colour of derived shadows is always affected by that of the body towards which they are cast. To prove this: let an opaque body be placed between the plane s c t d and the blue light d e and the red light a b, then I say that d e, the blue light, will fall on the whole surface s c t d excepting at o p which is covered by the shadow of the body q r, as is shown by the straight lines d q o e r p. And the same occurs with the light a b which falls on the whole surface s c t d excepting at the spot obscured by the shadow q r; as is shown by the lines d q o, and e r p. Hence we may conclude that the shadow n m is exposed to the blue light d e; but, as the red light a b cannot fall there, n m will appear as a blue shadow on a red background tinted with blue, because on the surface s c t d both lights can fall. But in the shadows only one single light falls; for this reason these shadows are of medium depth, since, if no light whatever mingled with the shadow, it would be of the first degree of darkness &c. But in the shadow at o p the blue light does not fall, because the body q r interposes and intercepts it there. Only the red light a b falls there and tinges the shadow of a red hue and so a ruddy shadow appears on the background of mingled red and blue.

The shadow of q r at o p is red, being caused by the blue light d e; and the shadow of q r at o' p' is blue being caused by the red light a b. Hence we say that the blue light in this instance causes a red derived shadow from the opaque body q' r',

while the red light causes the same body to cast a blue derived shadow; but the primary shadow [on the dark side of the body itself] is not of either of those hues, but a mixture of red and blue.

The derived shadows will be equal in depth if they are produced by lights of equal strength and at an equal distance; this is proved. [Footnote 53: The text is unfinished in the original.]

[Footnote: In the original diagram Leonardo has written within the circle q r corpo obroso (body in shadow); at the spot marked A, luminoso azzurro (blue luminous body); at B, luminoso rosso (red luminous body). At E we read ombra azzurra (blue tinted shadow) and at D ombra rossa (red tinted shadow).]

On the nature of colours (277. 278).

277.

No white or black is transparent.

278.

OF PAINTING.

[Footnote 2: See Footnote 3] Since white is not a colour but the neutral recipient of every colour [Footnote 3: il bianco non e

colore ma e inpotentia ricettiva d'ogni colore (white is not a colour, but the neutral recipient of every colour). LEON BATT. ALBERTI "Della pittura" libro I, asserts on the contrary: "Il bianco e'l nero non sono veri colori, ma sono alteratione delli altri colori" (ed. JANITSCHEK, p. 67; Vienna 1877).], when it is seen in the open air and high up, all its shadows are bluish; and this is caused, according to the 4th [prop.], which says: the surface of every opaque body assumes the hue of the surrounding objects. Now this white [body] being deprived of the light of the sun by the interposition of some body between the sun and itself, all that portion of it which is exposed to the sun and atmosphere assumes the colour of the sun and atmosphere; the side on which the sun does not fall remains in shadow and assumes the hue of the atmosphere. And if this white object did not reflect the green of the fields all the way to the horizon nor get the brightness of the horizon itself, it would certainly appear simply of the same hue as the atmosphere.

On gradations in the depth of colours (279. 280).

279.

Since black, when painted next to white, looks no blacker than when next to black; and white when next to black looks no whiter than white, as is seen by the images transmitted through a small hole or by the edges of any opaque screen ...

280.

OF COLOURS.

Of several colours, all equally white, that will look whitest which is against the darkest background. And black will look intensest against the whitest background.

And red will look most vivid against the yellowest background; and the same is the case with all colours when surrounded by their strongest contrasts.

On the reflection of colours (281-283).

281.

PERSPECTIVE.

Every object devoid of colour in itself is more or less tinged by the colour [of the object] placed opposite. This may be seen by experience, inasmuch as any object which mirrors another assumes the colour of the object mirrored in it. And if the surface thus partially coloured is white the portion which has a red reflection will appear red, or any other colour, whether bright or dark.

PERSPECTIVE.

Every opaque and colourless body assumes the hue of the colour reflected on it; as happens with a white wall.

282.

PERSPECTIVE.

That side of an object in light and shade which is towards the light transmits the images of its details more distinctly and immediately to the eye than the side which is in shadow.

PERSPECTIVE.

The solar rays reflected on a square mirror will be thrown back to distant objects in a circular form.

PERSPECTIVE.

Any white and opaque surface will be partially coloured by reflections from surrounding objects.

[Footnote 281. 282: The title line of these chapters is in the original simply "pro", which may be an abbreviation for either Propositione or Prospettiva--taking Prospettiva of course in its

widest sense, as we often find it used in Leonardo's writings. The title "pro" has here been understood to mean Prospettiva, in accordance with the suggestion afforded by page 10b of this same MS., where the first section is headed Prospettiva in full (see No. 94), while the four following sections are headed merely "pro" (see No. 85).]

283.

WHAT PORTION OF A COLOURED SURFACE OUGHT IN REASON TO BE THE MOST

INTENSE.

If a is the light, and b illuminated by it in a direct line, c, on which the light cannot fall, is lighted only by reflection from b which, let us say, is red. Hence the light reflected from it, will be affected by the hue of the surface causing it and will tinge the surface c with red. And if c is also red you will see it much more intense than b; and if it were yellow you would see there a colour between yellow and red.

On the use of dark and light colours in painting (284--286).

284.

WHY BEAUTIFUL COLOURS MUST BE IN THE [HIGHEST] LIGHT.

Since we see that the quality of colour is known [only] by means of light, it is to be supposed that where there is most light the true character of a colour in light will be best seen; and where there is most shadow the colour will be affected by the tone of that. Hence, O Painter! remember to show the true quality of colours in bright lights.

285.

An object represented in white and black will display stronger relief than in any other way; hence I would remind you O Painter! to dress your figures in the lightest colours you can, since, if you put them in dark colours, they will be in too slight relief and inconspicuous from a distance. And the reason is that the shadows of all objects are dark. And if you make a dress dark there is little variety in the lights and shadows, while in light colours there are many grades.

286.

OF PAINTING.

Colours seen in shadow will display more or less of their natural brilliancy in proportion as they are in fainter or deeper shadow.

But if these same colours are situated in a well-lighted place, they will appear brighter in proportion as the light is more brilliant.

THE ADVERSARY.

The variety of colours in shadow must be as great as that of the colours in the objects in that shadow.

THE ANSWER.

Colours seen in shadow will display less variety in proportion as the shadows in which they lie are deeper. And evidence of this is to be had by looking from an open space into the doorways of dark and shadowy churches, where the pictures which are painted in various colours all look of uniform darkness.

Hence at a considerable distance all the shadows of different colours will appear of the same darkness.

It is the light side of an object in light and shade which shows the true colour.

On the colours of the rainbow (287. 288).

287.

Treat of the rainbow in the last book on Painting, but first write the book on colours produced by the mixture of other colours, so as to be able to prove by those painters' colours how the colours of the rainbow are produced.

288.

WHETHER THE COLOURS OF THE RAINBOW ARE PRODUCED BY THE SUN.

The colours of the rainbow are not produced by the sun, for they occur in many ways without the sunshine; as may be seen by holding a glass of water up to the eye; when, in the glass--where there are those minute bubbles always seen in coarse glass--each bubble, even though the sun does not fall on it, will produce on one side all the colours of the rainbow; as you may see by placing the glass between the day light and your eye in such a way as that it is close to the eye, while on one side the glass admits the [diffused] light of the atmosphere, and on the other side the shadow of the wall on one side of the window; either left or right, it matters not which. Then, by turning the glass round you will see these colours all round the bubbles in the glass &c. And the rest shall be said in its place.

THAT THE EYE HAS NO PART IN PRODUCING THE COLOURS OF THE RAINBOW.

In the experiment just described, the eye would seem to have some

share in the colours of the rainbow, since these bubbles in the glass do not display the colours except through the medium of the eye. But, if you place the glass full of water on the window sill, in such a position as that the outer side is exposed to the sun's rays, you will see the same colours produced in the spot of light thrown through the glass and upon the floor, in a dark place, below the window; and as the eye is not here concerned in it, we may evidently, and with certainty pronounce that the eye has no share in producing them.

OF THE COLOURS IN THE FEATHERS OF CERTAIN BIRDS.

There are many birds in various regions of the world on whose feathers we see the most splendid colours produced as they move, as we see in our own country in the feathers of peacocks or on the necks of ducks or pigeons, &c.

Again, on the surface of antique glass found underground and on the roots of turnips kept for some time at the bottom of wells or other stagnant waters [we see] that each root displays colours similar to those of the real rainbow. They may also be seen when oil has been placed on the top of water and in the solar rays reflected from the surface of a diamond or beryl; again, through the angular facet of a beryl every dark object against a background of the atmosphere or any thing else equally pale-coloured is surrounded by these rainbow colours between the atmosphere and the dark body; and in many other

circumstances which I will not mention, as these suffice for my purpose.

VI.

'Prospettiva de' colri' (Perspective of Colour)

and

'Prospettiva aerea' (Aerial Perspective).

Leonardo distinctly separates these branches of his subject, as may be seen in the beginning of No. 295. Attempts have been made to cast doubts on the results which Leonardo arrived at by experiment on the perspective of colour, but not with justice, as may be seen from the original text of section 294.

The question as to the composition of the atmosphere, which is inseparable from a discussion on Aerial Perspective, forms a separate theory which is treated at considerable length. Indeed the author enters into it so fully that we cannot escape the conviction that he must have dwelt with particular pleasure on this part of his subject, and that he attached great importance to giving it a character of general applicability.

General rules (289--291).

289.

The variety of colour in objects cannot be discerned at a great distance, excepting in those parts which are directly lighted up by the solar rays.

290.

As to the colours of objects: at long distances no difference is perceptible in the parts in shadow.

291.

OF THE VISIBILITY OF COLOURS.

Which colour strikes most? An object at a distance is most conspicuous, when it is lightest, and the darkest is least visible.

An exceptional case.

292.

Of the edges [outlines] of shadows. Some have misty and ill defined edges, others distinct ones.

No opaque body can be devoid of light and shade, except it is in a mist, on ground covered with snow, or when snow is falling on the open country which has no light on it and is surrounded with darkness.

And this occurs [only] in spherical bodies, because in other bodies which have limbs and parts, those sides of limbs which face each other reflect on each other the accidental [hue and tone] of their surface.

An experiment.

293.

ALL COLOURS ARE AT A DISTANCE UNDISTINGUISHABLE AND UNDISCERNIBLE.

All colours at a distance are undistinguishable in shadow, because an object which is not in the highest light is incapable of transmitting its image to the eye through an atmosphere more luminous than itself; since the lesser brightness must be absorbed by the greater. For instance: We, in a house, can see that all the colours on the surface of the walls are clearly and instantly visible when the windows of the house are open; but if we were to go out of the house and look in at the windows from a little distance to see the paintings on those walls, instead of the paintings we

should see an uniform deep and colourless shadow.

The practice of the prospettiva de colori.

294.

HOW A PAINTER SHOULD CARRY OUT THE PERSPECTIVE OF COLOUR IN PRACTICE.

In order to put into practice this perspective of the variation and loss or diminution of the essential character of colours, observe at every hundred braccia some objects standing in the landscape, such as trees, houses, men and particular places. Then in front of the first tree have a very steady plate of glass and keep your eye very steady, and then, on this plate of glass, draw a tree, tracing it over the form of that tree. Then move it on one side so far as that the real tree is close by the side of the tree you have drawn; then colour your drawing in such a way as that in colour and form the two may be alike, and that both, if you close one eye, seem to be painted on the glass and at the same distance. Then, by the same method, represent a second tree, and a third, with a distance of a hundred braccia between each. And these will serve as a standard and guide whenever you work on your own pictures, wherever they may apply, and will enable you to give due distance in those works. [14] But I have found that as a rule the second is 4/5 of the first when it is 20 braccia beyond it.

[Footnote: This chapter is one of those copied in the Manuscript of the Vatican library Urbinas 1270, and the original text is rendered here with no other alterations, but in the orthography. H. LUDWIG, in his edition of this copy translates lines 14 and 15 thus: "Ich finde aber als Regel, dass der zweite um vier Funftel des ersten abnimmt, wenn er namlich zwanzig Ellen vom ersten entfernt ist (?)". He adds in his commentary: "Das Ende der Nummer ist wohl jedenfalls verstummelt". However the translation given above shows that it admits of a different rendering.]

The rules of aerial perspective (295--297).

295.

OF AERIAL PERSPECTIVE.

There is another kind of perspective which I call Aerial Perspective, because by the atmosphere we are able to distinguish the variations in distance of different buildings, which appear placed on a single line; as, for instance, when we see several buildings beyond a wall, all of which, as they appear above the top of the wall, look of the same size, while you wish to represent them in a picture as more remote one than another and to give the effect of a somewhat dense atmosphere. You know that in an atmosphere of equal density the remotest objects seen through it, as mountains, in

consequence of the great quantity of atmosphere between your eye and them--appear blue and almost of the same hue as the atmosphere itself [Footnote 10: quado il sole e per leuante (when the sun is in the East). Apparently the author refers here to morning light in general. H. LUDWIG however translates this passage from the Vatican copy "wenn namlich die Sonne (dahinter) im Osten steht".] when the sun is in the East [Footnote 11: See Footnote 10]. Hence you must make the nearest building above the wall of its real colour, but the more distant ones make less defined and bluer. Those you wish should look farthest away you must make proportionately bluer; thus, if one is to be five times as distant, make it five times bluer. And by this rule the buildings which above a [given] line appear of the same size, will plainly be distinguished as to which are the more remote and which larger than the others.

296.

The medium lying between the eye and the object seen, tinges that object with its colour, as the blueness of the atmosphere makes the distant mountains appear blue and red glass makes objects seen beyond it, look red. The light shed round them by the stars is obscured by the darkness of the night which lies between the eye and the radiant light of the stars.

297.

Take care that the perspective of colour does not disagree with the size of your objects, hat is to say: that the colours diminish from their natural [vividness] in proportion as the objects at various distances dimmish from their natural size.

On the relative density of the atmosphere (298--290).

298.

WHY THE ATMOSPHERE MUST BE REPRESENTED AS PALER TOWARDS THE LOWER

PORTION.

Because the atmosphere is dense near the earth, and the higher it is the rarer it becomes. When the sun is in the East if you look towards the West and a little way to the South and North, you will see that this dense atmosphere receives more light from the sun than the rarer; because the rays meet with greater resistance. And if the sky, as you see it, ends on a low plain, that lowest portion of the sky will be seen through a denser and whiter atmosphere, which will weaken its true colour as seen through that medium, and there the sky will look whiter than it is above you, where the line of sight travels through a smaller space of air charged with heavy vapour. And if you turn to the East, the atmosphere will appear darker as you look lower down because the luminous rays pass less freely through the lower atmosphere.

299.

OF THE MODE OF TREATING REMOTE OBJECTS IN PAINTING.

It is easy to perceive that the atmosphere which lies closest to the level ground is denser than the rest, and that where it is higher up, it is rarer and more transparent. The lower portions of large and lofty objects which are at a distance are not much seen, because you see them along a line which passes through a denser and thicker section of the atmosphere. The summits of such heights are seen along a line which, though it starts from your eye in a dense atmosphere, still, as it ends at the top of those lofty objects, ceases in a much rarer atmosphere than exists at their base; for this reason the farther this line extends from your eye, from point to point the atmosphere becomes more and more rare. Hence, O Painter! when you represent mountains, see that from hill to hill the bases are paler than the summits, and in proportion as they recede beyond each other make the bases paler than the summits; while, the higher they are the more you must show of their true form and colour.

On the colour of the atmosphere (300-307).

300.

OF THE COLOUR OF THE ATMOSPHERE.

I say that the blueness we see in the atmosphere is not intrinsic colour, but is caused by warm vapour evaporated in minute and insensible atoms on which the solar rays fall, rendering them luminous against the infinite darkness of the fiery sphere which lies beyond and includes it. And this may be seen, as I saw it by any one going up [Footnote 5: With regard to the place spoken of as M'oboso (compare No. 301 line 20) its identity will be discussed under Leonardo's Topographical notes in Vol. II.] Monboso, a peak of the Alps which divide France from Italy. The base of this mountain gives birth to the four rivers which flow in four different directions through the whole of Europe. And no mountain has its base at so great a height as this, which lifts itself almost above the clouds; and snow seldom falls there, but only hail in the summer, when the clouds are highest. And this hail lies [unmelted] there, so that if it were not for the absorption of the rising and falling clouds, which does not happen twice in an age, an enormous mass of ice would be piled up there by the hail, and in the middle of July I found it very considerable. There I saw above me the dark sky, and the sun as it fell on the mountain was far brighter here than in the plains below, because a smaller extent of atmosphere lay between the summit of the mountain and the sun. Again as an illustration of the colour of the atmosphere I will mention the smoke of old and dry wood, which, as it comes out of a chimney, appears to turn very blue, when seen between the eye and the dark distance. But as it

rises, and comes between the eye and the bright atmosphere, it at once shows of an ashy grey colour; and this happens because it no longer has darkness beyond it, but this bright and luminous space. If the smoke is from young, green wood, it will not appear blue, because, not being transparent and being full of superabundant moisture, it has the effect of condensed clouds which take distinct lights and shadows like a solid body. The same occurs with the atmosphere, which, when overcharged with moisture appears white, and the small amount of heated moisture makes it dark, of a dark blue colour; and this will suffice us so far as concerns the colour of the atmosphere; though it might be added that, if this transparent blue were the natural colour of the atmosphere, it would follow that wherever a larger mass air intervened between the eye and the element of fire, the azure colour would be more intense; as we see in blue glass and in sapphires, which are darker in proportion as they are larger. But the atmosphere in such circumstances behaves in an opposite manner, inasmuch as where a greater quantity of it lies between the eye and the sphere of fire, it is seen much whiter. This occurs towards the horizon. And the less the extent of atmosphere between the eye and the sphere of fire, the deeper is the blue colour, as may be seen even on low plains. Hence it follows, as I say, that the atmosphere assumes this azure hue by reason of the particles of moisture which catch the rays of the sun. Again, we may note the difference in particles of dust, or particles of smoke, in the sun beams admitted through holes into a dark chamber, when the former will look ash grey and the thin smoke will appear of a most

beautiful blue; and it may be seen again in in the dark shadows of distant mountains when the air between the eye and those shadows will look very blue, though the brightest parts of those mountains will not differ much from their true colour. But if any one wishes for a final proof let him paint a board with various colours, among them an intense black; and over all let him lay a very thin and transparent [coating of] white. He will then see that this transparent white will nowhere show a more beautiful blue than over the black--but it must be very thin and finely ground.

[Footnote 7: reta here has the sense of malanno.]

301.

Experience shows us that the air must have darkness beyond it and yet it appears blue. If you produce a small quantity of smoke from dry wood and the rays of the sun fall on this smoke, and if you then place behind the smoke a piece of black velvet on which the sun does not shine, you will see that all the smoke which is between the eye and the black stuff will appear of a beautiful blue colour. And if instead of the velvet you place a white cloth smoke, that is too thick smoke, hinders, and too thin smoke does not produce, the perfection of this blue colour. Hence a moderate amount of smoke produces the finest blue. Water violently ejected in a fine spray and in a dark chamber where the sun beams are admitted produces these blue rays and the more vividly if it is distilled water, and

thin smoke looks blue. This I mention in order to show that the blueness of the atmosphere is caused by the darkness beyond it, and these instances are given for those who cannot confirm my experience on Monboso.

302.

When the smoke from dry wood is seen between the eye of the spectator and some dark space [or object], it will look blue. Thus the sky looks blue by reason of the darkness beyond it. And if you look towards the horizon of the sky, you will see the atmosphere is not blue, and this is caused by its density. And thus at each degree, as you raise your eyes above the horizon up to the sky over your head, you will see the atmosphere look darker [blue] and this is because a smaller density of air lies between your eye and the [outer] darkness. And if you go to the top of a high mountain the sky will look proportionately darker above you as the atmosphere becomes rarer between you and the [outer] darkness; and this will be more visible at each degree of increasing height till at last we should find darkness.

That smoke will look bluest which rises from the driest wood and which is nearest to the fire and is seen against the darkest background, and with the sunlight upon it.

303.

A dark object will appear bluest in proportion as it has a greater mass of luminous atmosphere between it and the eye. As may be seen in the colour of the sky.

304.

The atmosphere is blue by reason of the darkness above it because black and white make blue.

305.

In the morning the mist is denser above than below, because the sun draws it upwards; hence tall buildings, even if the summit is at the same distance as the base have the summit invisible. Therefore, also, the sky looks darkest [in colour] overhead, and towards the horizon it is not blue but rather between smoke and dust colour.

The atmosphere, when full of mist, is quite devoid of blueness, and only appears of the colour of clouds, which shine white when the weather is fine. And the more you turn to the west the darker it will be, and the brighter as you look to the east. And the verdure of the fields is bluish in a thin mist, but grows grey in a dense one.

The buildings in the west will only show their illuminated side,

where the sun shines, and the mist hides the rest. When the sun rises and chases away the haze, the hills on the side where it lifts begin to grow clearer, and look blue, and seem to smoke with the vanishing mists; and the buildings reveal their lights and shadows; through the thinner vapour they show only their lights and through the thicker air nothing at all. This is when the movement of the mist makes it part horizontally, and then the edges of the mist will be indistinct against the blue of the sky, and towards the earth it will look almost like dust blown up. In proportion as the atmosphere is dense the buildings of a city and the trees in a landscape will look fewer, because only the tallest and largest will be seen.

Darkness affects every thing with its hue, and the more an object differs from darkness, the more we see its real and natural colour. The mountains will look few, because only those will be seen which are farthest apart; since, at such a distance, the density increases to such a degree that it causes a brightness by which the darkness of the hills becomes divided and vanishes indeed towards the top. There is less [mist] between lower and nearer hills and yet little is to be distinguished, and least towards the bottom.

306.

The surface of an object partakes of the colour of the light which illuminates it; and of the colour of the atmosphere which lies between the eye and that object, that is of the colour of the

transparent medium lying between the object and the eye; and among colours of a similar character the second will be of the same tone as the first, and this is caused by the increased thickness of the colour of the medium lying between the object and the eye.

307. OF PAINTING.

Of various colours which are none of them blue that which at a great distance will look bluest is the nearest to black; and so, conversely, the colour which is least like black will at a great distance best preserve its own colour.

Hence the green of fields will assume a bluer hue than yellow or white will, and conversely yellow or white will change less than green, and red still less.

VII.

On the Proportions and on the Movements of the Human Figure.

Leonardo's researches on the proportions and movements of the human figure must have been for the most part completed and written before the year 1498; for LUCA PACIOLO writes, in the dedication to Ludovico il Moro, of his book Divina Proportione, which was published in that year: "Leonardo da venci ... hauedo gia co tutta diligetia al degno libro de pictura e movimenti humani posto fine".

The selection of Leonardo's axioms contained in the Vatican copy attributes these words to the author: "e il resto si dira nella universale misura del huomo". (MANZI, p. 147; LUDWIG, No. 264). LOMAZZO, again, in his Idea del Tempio della Pittura Milano 1590, cap. IV, says: "Lionardo Vinci ... dimostro anco in figura tutte le proporzioni dei membri del corpo umano".

The Vatican copy includes but very few sections of the "Universale misura del huomo" and until now nothing has been made known of the original MSS. on the subject which have supplied the very extensive materials for this portion of the work. The collection at Windsor, belonging to her Majesty the Queen, includes by far the most important part of Leonardo's investigations on this subject, constituting about half of the whole of the materials here published; and the large number of original drawings adds greatly to the interest which the subject itself must command. Luca Paciolo would seem to have had these MSS. (which I have distinguished by the initials W. P.) in his mind when he wrote the passage quoted above. Still, certain notes of a later date--such as Nos. 360, 362 and 363, from MS. E, written in 1513--14, sufficiently prove that Leonardo did not consider his earlier studies on the Proportions and Movements of the Human Figure final and complete, as we might suppose from Luca Paciolo's statement. Or else he took the subject up again at a subsequent period, since his former researches had been carried on at Milan between 1490 and 1500. Indeed it is highly probable that

the anatomical studies which he was pursuing zvith so much zeal between 1510--16 should have led him to reconsider the subject of Proportion.

Preliminary observations (308. 309).

308.

Every man, at three years old is half the full height he will grow to at last.

309.

If a man 2 braccia high is too small, one of four is too tall, the medium being what is admirable. Between 2 and 4 comes 3; therefore take a man of 3 braccia in height and measure him by the rule I will give you. If you tell me that I may be mistaken, and judge a man to be well proportioned who does not conform to this division, I answer that you must look at many men of 3 braccia, and out of the larger number who are alike in their limbs choose one of those who are most graceful and take your measurements. The length of the hand is 1/3 of a braccio [8 inches] and this is found 9 times in man. And the face [Footnote 7: The account here given of the braccio is of importance in understanding some of the succeeding chapters. Testa must here be understood to mean the face. The statements in this section are illustrated in part on Pl. XI.] is the same, and from

the pit of the throat to the shoulder, and from the shoulder to the nipple, and from one nipple to the other, and from each nipple to the pit of the throat.

Proportions of the head and face (310-318).

310.

The space between the parting of the lips [the mouth] and the base of the nose is one-seventh of the face.

The space from the mouth to the bottom of the chin c d is the fourth part of the face and equal to the width of the mouth.

The space from the chin to the base of the nose e f is the third part of the face and equal to the length of the nose and to the forehead.

The distance from the middle of the nose to the bottom of the chin g h, is half the length of the face.

The distance from the top of the nose, where the eyebrows begin, to the bottom of the chin, i k, is two thirds of the face.

The space from the parting of the lips to the top of the chin l m, that is where the chin ends and passes into the lower lip of the

mouth, is the third of the distance from the parting of the lips to the bottom of the chin and is the twelfth part of the face. From the top to the bottom of the chin m n is the sixth part of the face and is the fifty fourth part of a man's height.

From the farthest projection of the chin to the throat o p is equal to the space between the mouth and the bottom of the chin, and a fourth of the face.

The distance from the top of the throat to the pit of the throat below q r is half the length of the face and the eighteenth part of a man's height.

From the chin to the back of the neck s t, is the same distance as between the mouth and the roots of the hair, that is three quarters of the head.

From the chin to the jaw bone v x is half the head and equal to the thickness of the neck in profile.

The thickness of the head from the brow to the nape is once and 3/4 that of the neck.

[Footnote: The drawings to this text, lines 1-10 are on Pl. VII, No. I. The two upper sketches of heads, Pl. VII, No. 2, belong to lines 11-14, and in the original are placed immediately below the sketches

reproduced on Pl. VII, No. 1.]

311.

The distance from the attachment of one ear to the other is equal to that from the meeting of the eyebrows to the chin, and in a fine face the width of the mouth is equal to the length from the parting of the lips to the bottom of the chin.

312.

The cut or depression below the lower lip of the mouth is half way between the bottom of the nose and the bottom of the chin.

The face forms a square in itself; that is its width is from the outer corner of one eye to the other, and its height is from the very top of the nose to the bottom of the lower lip of the mouth; then what remains above and below this square amounts to the height of such another square, a b is equal to the space between c d; d n in the same way to n c, and likewise s r, q p, h k are equal to each other.

It is as far between m and s as from the bottom of the nose to the chin. The ear is exactly as long as the nose. It is as far from x to j as from the nose to the chin. The parting of the mouth seen in profile slopes to the angle of the jaw. The ear should be as

high as from the bottom of the nose to the top of the eye-lid. The space between the eyes is equal to the width of an eye. The ear is over the middle of the neck, when seen in profile. The distance from 4 to 5 is equal to that from s to r.

[Footnote: See Pl. VIII, No. I, where the text of lines 3-13 is also given in facsimile.]

313.

(a b) is equal to (c d).

[Footnote: See Pl. VII, No. 3. Reference may also be made here to two pen and ink drawings of heads in profile with figured measurements, of which there is no description in the MS. These are given on Pl. XVII, No. 2.--A head, to the left, with part of the torso [W. P. 5a], No. 1 on the same plate is from MS. A 2b and in the original occurs on a page with wholly irrelevant text on matters of natural history. M. RAVAISSON in his edition of the Paris MS. A has reproduced this head and discussed it fully [note on page 12]; he has however somewhat altered the original measurements. The complicated calculations which M. RAVAISSON has given appear to me in no way justified. The sketch, as we see it, can hardly have been intended for any thing more than an experimental attempt to ascertain relative proportions. We do not find that Leonardo made use of circular lines in any other study of the proportions of the

human head. At the same time we see that the proportions of this sketch are not in accordance with the rules which he usually observed (see for instance No. 310).]

The head a f 1/6 larger than n f.

315.

From the eyebrow to the junction of the lip with the chin, and the angle of the jaw and the upper angle where the ear joins the temple will be a perfect square. And each side by itself is half the head.

The hollow of the cheek bone occurs half way between the tip of the nose and the top of the jaw bone, which is the lower angle of the setting on of the ear, in the frame here represented.

From the angle of the eye-socket to the ear is as far as the length of the ear, or the third of the face.

[Footnote: See Pl. IX. The text, in the original is written behind the head. The handwriting would seem to indicate a date earlier than 1480. On the same leaf there is a drawing in red chalk of two horsemen of which only a portion of the upper figure is here visible. The whole leaf measures 22 1/2 centimetres wide by 29 long, and is numbered 127 in the top right-hand corner.]

316.

From a to b--that is to say from the roots of the hair in front to the top of the head--ought to be equal to c d;--that is from the bottom of the nose to the meeting of the lips in the middle of the mouth. From the inner corner of the eye m to the top of the head a is as far as from m down to the chin s. s c f b are all at equal distances from each other.

[Footnote: The drawing in silver-point on bluish tinted paper--Pl. X--which belongs to this chapter has been partly drawn over in ink by Leonardo himself.]

317.

From the top of the head to the bottom of the chin is 1/9, and from the roots of the hair to the chin is 1/9 of the distance from the roots of the hair to the ground. The greatest width of the face is equal to the space between the mouth and the roots of the hair and is 1/12 of the whole height. From the top of the ear to the top of the head is equal to the distance from the bottom of the chin to the lachrymatory duct of the eye; and also equal to the distance from the angle of the chin to that of the jaw; that is the 1/16 of the whole. The small cartilage which projects over the opening of the ear towards the nose is half-way between the nape and the eyebrow; the thickness of the neck in profile is equal to the space between

the chin and the eyes, and to the space between the chin and the jaw, and it is 1/18 of the height of the man.

318.

a b, c d, e f, g h, i k are equal to each other in size excepting that d f is accidental.

[Footnote: See Pl. XI.]

Proportions of the head seen in front (319-321).

319.

a n o f are equal to the mouth.

a c and a f are equal to the space between one eye and the other.

n m o f q r are equal to half the width of the eye lids, that is from the inner [lachrymatory] corner of the eye to its outer corner; and in like manner the division between the chin and the mouth; and in the same way the narrowest part of the nose between the eyes. And these spaces, each in itself, is the 19th part of the head, n o is equal to the length of the eye or of the space between the eyes.

m c is 1/3 of n m measuring from the outer corner of the eyelids to the letter c. b s will be equal to the width of the nostril.

[Footnote: See Pl. XII.]

320.

The distance between the centres of the pupils of the eyes is 1/3 of the face. The space between the outer corners of the eyes, that is where the eye ends in the eye socket which contains it, thus the outer corners, is half the face.

The greatest width of the face at the line of the eyes is equal to the distance from the roots of the hair in front to the parting of the lips.

[Footnote: There are, with this section, two sketches of eyes, not reproduced here.]

321.

The nose will make a double square; that is the width of the nose at the nostrils goes twice into the length from the tip of the nose to the eyebrows. And, in the same way, in profile the distance from the extreme side of the nostril where it joins the cheek to the tip of the nose is equal to the width of the nose in front from one nostril

to the other. If you divide the whole length of the nose--that is from the tip to the insertion of the eyebrows, into 4 equal parts, you will find that one of these parts extends from the tip of the nostrils to the base of the nose, and the upper division lies between the inner corner of the eye and the insertion of the eyebrows; and the two middle parts [together] are equal to the length of the eye from the inner to the outer corner.

[Footnote: The two bottom sketches on Pl. VII, No. 4 face the six lines of this section,--With regard to the proportions of the head in profile see No. 312.]

322.

The great toe is the sixth part of the foot, taking the measure in profile, on the inside of the foot, from where this toe springs from the ball of the sole of the foot to its tip a b; and it is equal to the distance from the mouth to the bottom of the chin. If you draw the foot in profile from the outside, make the little toe begin at three quarters of the length of the foot, and you will find the same distance from the insertion of this toe as to the farthest prominence of the great toe.

323.

For each man respectively the distance between a b is equal to c

d.

324.

Relative proportion of the hand and foot.

The foot is as much longer than the hand as the thickness of the arm at the wrist where it is thinnest seen facing.

Again, you will find that the foot is as much longer than the hand as the space between the inner angle of the little toe to the last projection of the big toe, if you measure along the length of the foot.

The palm of the hand without the fingers goes twice into the length of the foot without the toes.

If you hold your hand with the fingers straight out and close together you will find it to be of the same width as the widest part of the foot, that is where it is joined onto the toes.

And if you measure from the prominence of the inner ancle to the end of the great toe you will find this measure to be as long as the whole hand.

From the top angle of the foot to the insertion of the toes is equal

to the hand from wrist joint to the tip of the thumb.

The smallest width of the hand is equal to the smallest width of the foot between its joint into the leg and the insertion of the toes.

The width of the heel at the lower part is equal to that of the arm where it joins the hand; and also to the leg where it is thinnest when viewed in front.

The length of the longest toe, from its first division from the great toe to its tip is the fourth of the foot from the centre of the ancle bone to the tip, and it is equal to the width of the mouth. The distance between the mouth and the chin is equal to that of the knuckles and of the three middle fingers and to the length of their first joints if the hand is spread, and equal to the distance from the joint of the thumb to the outset of the nails, that is the fourth part of the hand and of the face.

The space between the extreme poles inside and outside the foot called the ancle or ancle bone a b is equal to the space between the mouth and the inner corner of the eye.

325.

The foot, from where it is attached to the leg, to the tip of the great toe is as long as the space between the upper part of the chin

and the roots of the hair a b; and equal to five sixths of the face.

326.

a d is a head's length, c b is a head's length. The four smaller toes are all equally thick from the nail at the top to the bottom, and are 1/13 of the foot.

[Footnote: See Pl. XIV, No. 1, a drawing of a foot with the text in three lines below it.]

327.

The whole length of the foot will lie between the elbow and the wrist and between the elbow and the inner angle of the arm towards the breast when the arm is folded. The foot is as long as the whole head of a man, that is from under the chin to the topmost part of the head[Footnote 2: nel modo che qui i figurato. See Pl. VII, No. 4, the upper figure. The text breaks off at the end of line 2 and the text given under No. 321 follows below. It may be here remarked that the second sketch on W. P. 311 has in the original no explanatory text.] in the way here figured.

Proportions of the leg (328-331).

328.

The greatest thickness of the calf of the leg is at a third of its height a b, and is a twentieth part thicker than the greatest thickness of the foot.

a c is half of the head, and equal to d b and to the insertion of the five toes e f. d k diminishes one sixth in the leg g h. g h is 1/3 of the head; m n increases one sixth from a e and is 7/12 of the head, o p is 1/10 less than d k and is 6/17 of the head. a is at half the distance between b q, and is 1/4 of the man. r is half way between s and b[Footnote 11: b is here and later on measured on the right side of the foot as seen by the spectator.]. The concavity of the knee outside r is higher than that inside a. The half of the whole height of the leg from the foot r, is half way between the prominence s and the ground b. v is half way between t and b. The thickness of the thigh seen in front is equal to the greatest width of the face, that is 2/3 of the length from the chin to the top of the head; z r is 5/6 of 7 to v; m n is equal to 7 v and is 1/4 of r b, x y goes 3 times into r b, and into r s.

[Footnote 22-35: The sketch illustrating these lines is on Pl. XIII, No. 2.]

[Footnote 22: a b entra in c f 6 e 6 in c n. Accurate

measurement however obliges us to read 7 for 6.] a b goes six
times into c f and six times into c n and is equal to g h; i
k l m goes 4 times into d f, and 4 times into d n and is 3/7 of
the foot; p q r s goes 3 times into d f, and 3 times into b n;
[Footnote: 25. y is not to be found on the diagram and x occurs
twice; this makes the passage very obscure.] x y is 1/8 of x f
and is equal to n q. 3 7 is 1/9 of n f; 4 5 is 1/10 of n f
[Footnote: 22-27. Compare with this lines 18-24 of No. 331, and the
sketch of a leg in profile Pl. XV.].

I want to know how much a man increases in height by standing on
tip-toe and how much p g diminishes by stooping; and how much it
increases at n q likewise in bending the foot.

[Footnote 34: e f 4 dal cazo. By reading i for e the sense
of this passage is made clear.] e f is four times in the distance
between the genitals and the sole of the foot; [Footnote 35: 2 is
not to be found in the sketch which renders the passage obscure. The
two last lines are plainly legible in the facsimile.] 3 7 is six
times from 3 to 2 and is equal to g h and i k.

[Footnote: The drawing of a leg seen in front Pl. XIII, No. 1
belongs to the text from lines 3-21. The measurements in this
section should be compared with the text No. 331, lines 1-13, and
the sketch of a leg seen in front on Pl. XV.]

329.

The length of the foot from the end of the toes to the heel goes twice into that from the heel to the knee, that is where the leg bone [fibula] joins the thigh bone [femur].

330.

a n b are equal; c n d are equal; n c makes two feet; n d makes 2 feet.

[Footnote: See the lower sketch, Pl. XIV, No. 1.]

331.

m n o are equal. The narrowest width of the leg seen in front goes 8 times from the sole of the foot to the joint of the knee, and is the same width as the arm, seen in front at the wrist, and as the longest measure of the ear, and as the three chief divisions into which we divide the face; and this measurement goes 4 times from the wrist joint of the hand to the point of the elbow. [14] The foot is as long as the space from the knee between a and b; and the patella of the knee is as long as the leg between r and s.

[18] The least thickness of the leg in profile goes 6 times from the sole of the foot to the knee joint and is the same width as the

space between the outer corner of the eye and the opening of the ear, and as the thickest part of the arm seen in profile and between the inner corner of the eye and the insertion of the hair.

a b c [d] are all relatively of equal length, c d goes twice from the sole of the foot to the centre of the knee and the same from the knee to the hip.

[28]a b c are equal; a to b is 2 feet--that is to say measuring from the heel to the tip of the great toe.

[Footnote: See Pl. XV. The text of lines 2-17 is to the left of the front view of the leg, to which it refers. Lines 18-27 are in the middle column and refer to the leg seen in profile and turned to the left, on the right hand side of the writing. Lines 20-30 are above, to the left and apply to the sketch below them.

Some farther remarks on the proportion of the leg will be found in No. 336, lines 6, 7.]

On the central point of the whole body.

332.

In kneeling down a man will lose the fourth part of his height.

When a man kneels down with his hands folded on his breast the navel will mark half his height and likewise the points of the elbows.

Half the height of a man who sits--that is from the seat to the top of the head--will be where the arms fold below the breast, and below the shoulders. The seated portion--that is from the seat to the top of the head--will be more than half the man's [whole height] by the length of the scrotum.

[Footnote: See Pl. VIII, No. 2.]

The relative proportions of the torso and of the whole figure.

333.

The cubit is one fourth of the height of a man and is equal to the greatest width of the shoulders. From the joint of one shoulder to the other is two faces and is equal to the distance from the top of the breast to the navel. [Footnote 9: dalla detta somita. It would seem more accurate to read here dal detto ombilico.] From this point to the genitals is a face's length.

[Footnote: Compare with this the sketches on the other page of the same leaf. Pl. VIII, No. 2.]

The relative proportions of the head and of the torso.

334.

From the roots of the hair to the top of the breast a b is the sixth part of the height of a man and this measure is equal.

From the outside part of one shoulder to the other is the same distance as from the top of the breast to the navel and this measure goes four times from the sole of the foot to the lower end of the nose.

The [thickness of] the arm where it springs from the shoulder in front goes 6 times into the space between the two outside edges of the shoulders and 3 times into the face, and four times into the length of the foot and three into the hand, inside or outside.

[Footnote: The three sketches Pl. XIV, No. 2 belong to this text.]

The relative proportions of the torso and of the leg (335. 336).

335.

a b c are equal to each other and to the space from the armpit of the shoulder to the genitals and to the distance from the tip of the fingers of the hand to the joint of the arm, and to the half of the breast; and you must know that c b is the third part of the height

of a man from the shoulders to the ground; d e f are equal to each other and equal to the greatest width of the shoulders.

[Footnote: See Pl. XVI, No. 1.]

336.

--Top of the chin--hip--the insertion of the middle finger. The end of the calf of the leg on the inside of the thigh.--The end of the swelling of the shin bone of the leg. [6] The smallest thickness of the leg goes 3 times into the thigh seen in front.

[Footnote: See Pl. XVII, No. 2, middle sketch.]

The relative proportions of the torso and of the foot.

337.

The torso a b in its thinnest part measures a foot; and from a to b is 2 feet, which makes two squares to the seat--its thinnest part goes 3 times into the length, thus making 3 squares.

[Footnote: See Pl, VII, No. 2, the lower sketch.]

The proportions of the whole figure (338-341).