Ancient and Medieval Visions of Light and Colour

Technische Universität Berlin, Winter Semester 2019

Lecturers:

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"Because you have seen me, you have believed" (John 20:29). But is seeing always believing? And how is seeing possible at all? Long before John the Evangelist wrote his Gospel around 90 AD, in which doubting Thomas required a verification for believing in Christ's resurrection, the question of what it means to see, how humans are able to see, and what is required for them to do so has been a central theme across scientific disciplines. Seeing, in premodern times, focused, rather frequently, on questions to do with the qualitative properties of light and color, and the role of the medium that was thought to transmit them to the human eye. In optics, however, explanations on the propagation of light, at times rooted in experimentation, also drew on geometry, thus fostering an early mathematization of the world. In theories of human cognition, considerations on light, color, and the medium were extended beyond their original contexts in order to account for the workings of human sensation, intellectual understanding, and discursive thought. Similarly, a wide range of cosmological and causational models relied on the interplay between light, color, and the medium, often drawing on optical theories, to explain ideas as fundamental as eduction and change. And even in premodern theology, light and color were at the heart of rationalizations, ranging from prophecy to rapture to the vision of God in the afterlife. The purpose of this seminar is to read select sources and secondary literature on seeing, light, and color (in English translation) in order to gain a deeper understanding of the fundamental roles that Premodern Visions of Light and Color had for premodern knowledge.

Course articulation:

- Block 1 – Light, Vision, and Colour in Theories of Perception and Knowledge
- Block 2 – Light, Vision, and Colour in Optical Theories
- Block 3 – Light, Vision, and Colour in Cosmology and Theology
- Block 4 – Light, Vision, and Colour in Metaphysics and Natural Philosophy

Classes:

Monday, 14 October, 15-17.
Friday, 13 December 2019, 9-18.
Saturday, 14 December 2019, 9-18.
Friday, 20 December 2019, 9-16.
Saturday, 21 December 2019, 9-16.

~ READER ~

1. Light, Vision, and Colour in Theories of Perception and Knowledge

Texts:

1. Aristotle, *The Soul*, book 2, chapters 7. Transl. Smith (Princeton, 1991), 32-34.
2. Plotinus, *Enneads*, V, 3, 8-9. Transl. Armstrong (Cambridge, 1984), 95-103.
3. al-Farabi*, On the Intellect*, excerpts. Transl. McGinnis and Reisman (Indianapolis 2007), 74-78.
4. Avicenna, *The Soul*, book 5, chapter 5. Transl. McGinnis and Reisman (Indianapolis 2007), 199-202.
5. Aquinas, *On the Soul*, book 2, chapter 7. Transl. Foster and Humphries (New Haven 1951).
6. Nicholas of Autrecourt, *Universal Treatise.* Transl. Kennedy, Arnold, and Millward (Milwaukee, 1971), 108-111.

Aristotle, *The Soul*

The object of sight is the visible, and what is visible is colour and a certain kind of object which can be described in words but which has no single name; what we mean by the second will be abundantly clear as we proceed. Whatever is visible is colour and colour is what lies upon what is in itself visible; 'in itself' here means not that visibility is involved in the definition of what thus underlies colour, but that that substratum contains in itself the cause of visibility. Every colour has in it the power to set in movement what is actually transparent; that power constitutes its very nature. That is why it is not visible except with the help of light; it is only in light that the colour of a thing is seen. Hence our first task is to explain what light is.

Now there clearly is something which is transparent, and by 'transparent' I mean what is visible, and yet not visible in itself, but rather owing its visibility to the colour of something else; of this character are air, water, and many solid bodies. Neither air nor water is transparent because it is air or water; they are transparent because each of them has contained in it a certain substance which is the same in both and is also found in the eternal upper body. Of this substance light is the activity—the activity of what is transparent qua transparent; where this power is present, there is also the potentiality of the contrary, viz. darkness. Light is as it were the proper colour of what is transparent, and exists whenever the potentially transparent is excited to actuality by the influence of fire or something resembling 'the uppermost body'; for fire too contains something which is one and the same with the substance in question.

We have now explained what the transparent is and what light is; light is neither fire nor any kind whatsoever of body nor an efflux from any kind of body (if it were, it would again itself be a kind of body)—it is the presence of fire or something resembling fire in what is transparent. It is certainly not a body, for two bodies cannot be present in the same place. The opposite of light is darkness; darkness is the absence from what is transparent of the corresponding positive state above characterized; clearly therefore, light is just the presence of that.

Empedocles (and with him all others who used the same forms of expression) was wrong in speaking of light as 'travelling' or being at a given moment between the earth and its envelope, its movement being unobservable by us; that view is contrary both to the clear evidence of argument and to the observed facts; if the distance traversed were short, the movement might have been unobservable, but where the distance is from extreme East to extreme West, the strain upon our powers of belief is too great.

What is capable of taking on colour is what in itself is colourless, as what can take on sound is what is soundless; what is colourless includes what is transparent and what is invisible or scarcely visible, i.e. what is dark. The latter is the same as what is transparent, when it is potentially, not of course when it is actually transparent; it is the same substance which is now darkness, now light.

Not everything that is visible depends upon light for its visibility. This is only true of the 'proper' colour of things. Some objects of sight which in light are invisible, in darkness stimulate the sense; that is, things that appear fiery or shining. This class of objects has no simple common name, but instances of it are fungi, horns, heads, scales, and eyes of fish. In none of these is what is seen their own proper colour. Why we see

these at all is another question. At present what is obvious is that what is seen in light is always colour. That is why without the help of light colour remains invisible. Its being colour at all means precisely its having in it the power to set in movement what is actually transparent, and the actuality of what is transparent is just light.

The following makes the necessity of a medium clear. If what has colour is placed in immediate contact with the eye, it cannot be seen. Colour sets in movement what is transparent, e.g. the air, and that, extending continuously from the object of the organ, sets the latter in movement. Democritus misrepresents the facts when he expresses the opinion that if the interspace were empty one could distinctly see an ant on the vault of the sky; that is an impossibility. Seeing is due to an affection or change of what has the perceptive faculty, and it cannot be affected by the seen colour itself; it remains that it must be affected by what comes between. Hence it is indispensable that there be something in between—if there were nothing, so far from seeing with greater distinctness, we should see nothing at all.

We have now explained the cause why colour cannot be seen otherwise than in light. Fire on the other hand is seen both in darkness and in light; this double possibility follows necessarily from our theory, for it is just fire that makes what is potentially transparent actually transparent.

The same account holds also of sound and smell; if the object of either of these senses is in immediate contact with the organ no sensation is produced. In both cases the object sets in movement only what lies between, and this in turn sets the organ in movement: if what sounds or smells is brought into immediate contact with the organ, no sensation will be produced. The same, in spite of all appearances, applies also to touch and taste; why there is this apparent difference will be clear later. What comes between in the case of sounds is air; the corresponding medium in the case of smell has no name. But, corresponding to what is transparent in the case of colour, there is a quality found both in air and water, which serves as a medium for what has smell; for animals that live in water seem to possess the sense of smell. Men and all other land animals that breathe, perceive smells only when they breathe air in. The explanation of this too will be given later.

Plotinus, *Enneads*

But as what sort of thing does Intellect see the intelligible, and as what sort of thing does it see itself? As for the intelligible, one should not look for something like colour or form in bodies; for the intelligibles exist before the existence of these; and the rational forming principle in the seeds which produce these are not form and colour; for both these and still more the intelligibles are naturally invisible. And they and those which possess them have the same nature, as do also the rational principle in the seed and the soul which possesses these [invisible principles of colour and form]. But the soul does not see what it possesses; for it did not even generate them, but this soul as well as the rational forming principles is an image; but that from which it came is the clear and the true and the primary, and so belongs to itself and exists for itself; but this [image], if it does not belong to something else and exist in something else, does not persist; for "it is proper to an image, since it belongs to something else, to come to exist in something else", unless it is in close dependence on that original. It does not even see, therefore, because it does not have enough light, but if it does see, it does not see itself but another thing perfected in something else. But there is none of this in the intelligible world, but there seeing and the seen coincide, and the seen is like the seeing and the seeing like the seen. Who then will tell what it is like? The seer: and Intellect is the seer. For here below also sight, since it is light, or rather united with light, sees light: for it sees colours; but in the intelligible world seeing is not through another [medium], but through itself, because it is not [directed] outside. Intellect therefore sees one light with another, not through another. Light then sees another light: it therefore itself sees itself. And this light shining in the soul illuminates it; that is, it makes it intelligent; that is, it makes it like itself, the light above. For if you consider that it is like the trace of light that comes to be in the soul and still more beautiful and greater and clearer, you will come near to the nature of Intellect and the intelligible. And again, this illumination gives the soul a clearer life, but a life which is not generative; on the contrary it turns the soul back upon itself and does not allow it to disperse, but makes it satisfied with the glory in itself; and it is certainly not a life of sense-perception either; for sense-perception looks outside and perceives the external world; but he who has received that light of the true realities sees, so to speak, the visible things no better, but their opposite.

The remaining possibility, then, is for the soul to have received an intelligent life, a trace of the life of Intellect: for the true realities are there. But the life and activity of Intellect is the first light shining primarily for itself and an outshining upon itself, at once illuminating and illuminated, the truly intelligible, both thinker and thought, seen by itself and needing no other that it may see, supplying itself with the power of seeing—for it is itself what it sees—known to us by that very power, so that the knowledge of it comes to us through itself; otherwise from where should we have the ability to speak about it? It is such a kind that it apprehends itself more clearly, but we apprehend it by means of it; by reasonings of this kind our soul also is led back up to it, considering itself to be an image of Intellect, as its life is a reflection and likeness of it, and when it thinks it becomes godlike and intellect-like; and if one asks it what sort of thing is that perfect universal Intellect which has primary knowledge of itself, it first comes to be in Intellect or makes room for Intellect to exercise its activity, and shows itself really in possession of the things of which it has the memory in itself, so that through soul which is its image one can in some way see Intellect, through the soul which is brought more precisely to its likeness, as far as a part of soul can come to likeness with Intellect.

It is probable, then, that he who intends to know what Intellect really is must know soul, and the most divine part of soul. This could happen also in this way, if you first of all separated the body from man (and, obviously, from yourself), and then the soul which forms it and, very thoroughly, sense perception and desires and passions and all the rest of such fooleries, since they incline so very much towards the mortal. What remains of soul is this which we said was an image of Intellect preserving something of its light, like the light of the sun which, beyond its spherical mass, shines around it and from it. Now one would not concede that the light of the sun exists by itself which is around the sun itself, springing from it and remaining around it, though one light comes from another, always going forth from that before it until it reaches us on the earth; but one will place all of it, including that which is around the sun itself in something else, so as not to assume that there is a space, that under the sun, which is empty of body. But the soul has arisen from Intellect as a light around it and is immediately dependent on it and not in something else but around it, and has no place, for neither has Intellect. So the light. of the sun is in the air, but the soul itself which is of this kind is pure, so that it itself and any other soul of the same kind can see it by itself. And soul must draw conclusions about what Intellect is like, starting its investigation from itself, but Intellect knows itself without drawing conclusions about itself; for it is always present to itself, but we are only so when we attain to it; for our life is divided and we have many lives, but Intellect has no need of another life or other lives, but the lives which it gives, it gives to others, not to itself: for it has no need of the worse, nor does it give itself the less when it has the all, nor the traces of reality when it has the primary realities, or rather does not have them, but is them itself. But if someone is unable to grasp this kind of soul which thinks purely, let him take the soul which forms opinions, and then ascend from this. But if he cannot even do this, let him take sense-perception which acquires the forms in broader extension and sense-perception by itself with its powers which is already in the forms. But if someone wants to, let him descend to the generative soul and go right on to what it makes, and then ascend from there, from the ultimate forms to the forms which are ultimate in the opposite sense, or, rather, to the primary forms.

Al-Farabi*, On the Intellect*

What Aristotle calls the "Active Intellect" in Book III of *De anima* is a separate form that has never been and never will be in matter in any way. In its species it is an actual intellect very similar to the acquired intellect. It is what makes the potential intellect an actual intellect, and it is what makes the potential intelligibles actual intelligibles.

The relation [of the active intellect] to the potential intellect is like the relation of the Sun to the eye, which is potentially vision as long as it is in darkness, for vision is potentially vision simply as long as it is in darkness. The meaning of darkness is potential transparency and the privation of actual transparency. The meaning of transparency is to be lit by something opposite that is luminous. So, when light comes about in vision and in the air and anything similar, vision becomes actual vision by the light that comes about in it, and colors become actually visible. In fact, we say that vision becomes actual vision not solely by light and actual transparency coming about in it, but also because when actual transparency comes about in it, the forms of visible things come about in it. Through the occurrence of the forms of visible things in vision, it becomes actual vision, and because [vision] was prepared beforehand by the rays of the Sun or something else to become actually transparent, and the air in contact with it also becomes actually transparent, anything

potentially visible now becomes actually visible. So, the principle by which vision becomes actual vision after having been potential vision, and by which visible things that had been potentially visible become actually visible, is the transparency that comes about in vision from the sun. In a similar manner, there comes about in the potential intellect a certain thing whose relation to it is like that of actual transparency to vision. The active intellect gives that thing to [the potential intellect], whereby it becomes a principle through which the potential intelligibles become actual intelligibles for [the intellect]. In the same way that the sun is what gives the eye actual vision and makes [potentially] visible things actually visible by the light it gives, so too the active intellect is what makes the potential intellect an actual intellect by the principle it gives it, and by that same [principle] the intelligibles become actual intelligibles.

The active intellect belongs to the same species as the acquired intellect. The forms of the immaterial beings above it have always been and always will be in it, although their existence in it follows an order different from the order in which they exist in the actual intellect. The reason for this is that what is lesser in the actual intellect is often ordered to be prior to what is more excellent on account of the fact that our ascent to things that are more perfect in their existence is often from things that are less so (as explained in *Posterior Analytics*), since we proceed from what is better known to us precisely to what is unknown, and that which is more perfect in its existence in itself is more unknown to us (I mean that our ignorance of it is greater). For this reason, the order of existents in the actual intellect has to be the reverse of their order in the active intellect, given that the active intellect first intellects the most perfect existent and then the next more perfect; for the forms that are now forms in matters are abstract forms in the active intellect not by virtue of having once existed in matters and then having been extracted. On the contrary, those forms [in the active intellect] have always been actual, whereas it is precisely by actually being given these forms that are in the active intellect that [the actual intellect] imitates prime matter and other matter. Furthermore, the existents whose origination was primarily intended for this world are those forms [in the active intellect], except that since they could be created here only in matters, these matters were generated. These forms are indivisible in the active intellect but divisible in matter. It is absolutely undeniable that the active intellect, which is indivisible or which is itself indivisible things, gives matter the semblances of what is in its substance, but matter receives it only as something divisible. This is something Aristotle also explained in his *De anima*.

There is a topic of investigation in what preceded, namely, that if these forms can exist without matters, what is the need to put them in matters, and how do they descend from the most perfect existence to the less perfect? There might be someone who says that this is done just so that matters may attain a more perfect existence, from which it would necessarily follow that those forms are generated just for the sake of matter. That, however, is contrary to Aristotle's opinion. Or we might say that all of these forms are in the active intellect potentially, but when we say "potentially" here, one should not understand it in the sense that the active intellect has the potentiality to receive these forms so that they would be in it in the future. We mean instead that it has a potentiality to put them in matter as forms, where this is the potentiality to act upon something else; for after all it is the active intellect that puts them in matter as forms.

Next, [the active intellect] aims to bring [those forms in matter] closer and closer to the immaterial forms until the acquired intellect comes to be, at which point the substance of man, or man by virtue of what constitutes his substance, becomes the closest thing possible to the active intellect. This is the ultimate happiness and the afterlife, which is that the final thing by which man becomes a substance comes about for him, and he attains his final perfection, which is that the final thing through which he becomes a substance performs the final action by virtue of which he becomes a substance. This is what is meant by the afterlife. When [the acquired intellect] does not act on some other thing outside of itself, where to act is to cause itself to exist, then its essence, its action, and the fact that it acts are one and the same thing. At that point, it has absolutely no need for the body to be a matter for it in order to subsist, and it has absolutely no need in any of its actions to seek the help of a faculty of a soul in a body, or to use any corporeal instrument whatsoever. The least perfect existence of its essence is when it requires the body to be a matter for it in order to subsist as an existent, and when it is a form in a body or a corporeal matter as a whole. Above that, it does not require the body to be a matter for it in order to subsist, but in order to perform its actions, or many of them, it needs to use a corporeal faculty and to seek the aid of its action, for example, sensory perception and imagination. Its most perfect existence, though, is to reach the state we just mentioned.

Now, it has been explained in *De anima* that the active intellect exists. Furthermore, it is clear that the active intellect does not always act but rather sometimes acts and sometimes does not. It necessarily follows, then, that this is the result either of the action it performs or the thing on which it acts according to different relations, in which case it would change from one relation to another. If it does not always exist according to its ultimate perfection, then it would change not just from one relation to another but also in its very being, since its ultimate perfection is with respect to its substance. Then, in its very substance it would at one time be in potentiality and at another time in actuality, in which case what belongs to its [essence] in potentiality would be the matter of what belongs to it in actuality—except that we have posited that it is separate from every kind of matter. This being the case, it is always at its ultimate perfection, changing necessarily [only] from one relation to another. Therefore, the imperfection is not in itself, but rather either in as much as it does not always encounter the thing on which it acts, because it does not find ready the matter and subject on which it acts, or there is an external obstacle [that] later disappears, or both of these things together. It is clear from this that [the active intellect] is not sufficient itself to be the First Principle of all existents, since it needs to be given some matter on which to act and needs the obstacle to be removed. As it is insufficient in its essence and substance to produce all things, there is thus in its substance an inability to produce many of the existent things. Anything that is deficient in its substance is not sufficient enough to have its existence be by virtue of itself without being by virtue of something else. It necessarily follows that there is another principle for its existence and that there is another cause that aids it in producing the matter on which it acts. It is clear that the subjects on which the active intellect acts are either bodies or powers in bodies that are generated and corrupt. In fact, it has been explained in *De generatione et corruptione* that the celestial bodies are the first efficient causes of those bodies. It is these [celestial] bodies, then, that provide the active intellect with the matters and subjects on which it acts.

Every celestial body is set in motion only by a mover that is neither a body nor in a body in any way. [This mover] is the cause of [the celestial body's] existence, in as much as it is that by virtue of which [the celestial body] is a substance, but its level, in terms of the existence that is [the celestial body's] substance, is the same as that body. The mover of the more perfect of [the celestial bodies] is the more perfect in terms of existence, and the more perfect in terms of existence is the first heaven. So the more perfect in terms of existence is the mover of the first heaven. However, the mover of the first heaven is a principle by virtue of which two distinct things exist. One is what constitutes the substance of the first heaven, namely, a corporeal substance or something corporeal. The other is the mover of the sphere of fixed stars, namely, an essence that is neither a body nor in a body. [Now, since the mover of the first heaven is a principle of two distinct things], it cannot produce both things in a single way and by a single thing in its essence by virtue of which it is a substance. On the contrary, it [must produce them] by two natures, one of which is more perfect than the other, since the nature by which it produces the more perfect thing—that is, the one that is not a body nor in a body—is more perfect than the nature by which it produces a corporeal thing, that is, the one that is less perfect. Therefore, it is a substance through two natures, only through both of which does it exist. Therefore, its existence has a principle, since whatever is divisible has a cause that makes it a substance. Therefore, the mover of the first heaven certainly cannot be the First Principle for all existing things; rather, it must [itself] have a principle, and that principle undoubtedly has a more perfect existence than it. Now, since the mover of the first heaven is neither matter nor in matter, it necessarily follows that it is an intellect in its substance, in which case it intellects its own essence and the essence of the thing that is the principle of its existence. Clearly, of its two natures, the nature it has that intellects something about the principle of its existence is the more perfect, whereas the nature it has by which it intellects itself is the less perfect of them. Nothing more than these two is required to divide its essence into two natures.

The Principle of the mover of the first heaven—that is, the principle by virtue of which it is a substance—is necessarily one in all respects. It is absolutely impossible for there to be an existent more perfect than It or for It to have any principle. Therefore, It is the Principle of all the principles and the First Principle of all existing things. This is the Principle that Aristotle discusses in Book Lambda of *Metaphysics*. While each one of those other [principles] is also an intellect, this One is the First Intellect, the First Existent, the First One, and the First Truth; it is only in an ordered succession from It that these others become intellects. Further investigation into these things lies outside our aim here.

Avicenna, *The Soul*

We say that the human soul is at one time something intellecting potentially and thereafter becomes something actually intellecting. Now whatever is brought from potency to act does so only on account of a cause in act that brings it out. So there is a cause that brings our souls from potency to act with regard to the intelligibles. Since it is the cause with respect to providing the intelligible forms, it is nothing but an actual intellect in whom the principles of the intellectual forms are separate (*mujarrada*) [from matter], and whose relation to our souls is the relation of the Sun to our vision. Just as the Sun is actually visible in itself and through its light it makes actually visible what is not actually visible, so likewise is the state of this intellect vis-á-vis our souls; for when the intellecting faculty reviews the particulars that are in the imagery [faculty], and the Active Intellect sheds light into us upon them (which we discussed), the things abstracted from matter and its associations are altered and impressed upon the rational soul. ["Being altered" is] not in the sense that [the particulars] themselves are transferred from the imagery to our intellect, nor [is "being impressed"] in the sense that the connotational attribute immersed in the [material] associations (which in itself and with regard to its very being is separate (*mujarrada*) [from matter]) makes something like itself. Quite the contrary, [the alteration and being impressed] is in the sense that reviewing [the things abstracted from matter and its associations] prepares the soul in order that the thing separate from matter [coming] from the Active Intellect [i.e., the intellectual forms] flows down upon them; for discursive thought and selective attention are certain motions that prepare the soul in a way to receive what flows down just as middle terms prepare [the soul] to receive the conclusion in the most convincing way, although the first is according to one way and the second according to another, as you will come to know.

So when a certain relation to this form happens to the rational soul by means of the light shed by the Active Intellect, then from [the relation to the form] there comes to be in [the soul] something that in one way is of its genus and in another way is not, just as when light falls on colored objects, in the seeing of them it produces an effect that is not in every way [reduced] to their sum. So the things in the imagery [faculty], which are potentially intelligible, become actually intelligible— not themselves but what is acquired from them. In fact, just as the effect resulting from the sensible forms by means of the light is not itself those forms, but rather something related to them that is engendered by means of the light in the recipient facing [the light], so likewise when the rational soul reviews those forms in the imagery [faculty] and the light of the Active Intellect comes into a type of contact with them, then they are prepared so that from the light of the Active Intellect they come to be within [the rational soul] the abstract version of those forms [free] from [material] taints.

As soon as the essential aspects of [those forms] are distinguished from their accidental aspects on the part of the human intellect, and what makes them similar to the forms of the imagery is distinguished from what makes them different, the connotational attributes that show no difference from those become one in the intellect itself by comparison of similarity, but those connotational attributes that bear comparison to what is different become many connotational attributes and so the intellect has the ability both to consider one of the connotational attributes to be many and to consider the multiple connotational attributes to be one. There are two ways that the many can be considered one. The first is in that when the numerically many differing connotations related to the forms of the imagery do not differ in definition, they become a single connotational attribute. The second way is by combining the many different connotations of genera and differences into a connotational attribute that is singular in the definition. The way to make one connotational attribute many is the reverse of these two processes.

This is one of the properties of the human intellect. It does not belong to any of the other faculties; for they perceive the many as a many as it is and the one as one as it is, whereas they cannot perceive the simple one, but rather the one inasmuch as it is a whole combined of things and their accidents. Also they cannot separate out the accidental aspects and extracts them from the essential aspects. So, when the senses present a given form to the imagery [faculty] and the imagery [faculty] presents it to the intellect, the intellect takes a single connotational attribute from it. Then if another form of the same species is presented to it—"another" only in number—the intellect by no means takes any form different from what was taken, unless it is due to the accident that is particular to this inasmuch as it is that accident such that it takes it one time as separate [of all accidents] and another time with that accident. This is why it is said that Zayd and 'Amr have one connotational attribute in terms of "humanness," not on the basis of the fact that the humanness associated with the particular properties of 'Amr is the very same humanness associated with the particular properties of Zayd, as though there were a single thing belonging to Zayd and 'Amr, as is the case with

friendship or power. Instead, "humanness" in terms of existence is multiple, and there is no existence belonging to some one common humanness in external reality unless it is that very humanness of Zayd and 'Amr. We will endeavor to explain this in the discipline of philosophy [i.e., metaphysics]. What is intended [here] is that since the first of [the two forms, e.g., Zayd's form of humanness] provided the soul with the form of "humanness," the second [form, e.g., 'Amr's form of humanness] does not provide anything at all. Instead, the connotational attribute imprinted in the soul by both is a single one, that is, the one from the first presentation of the imagery, while the second presentation has no influence, for either one of them could have preceded and left this very same imprint in the soul, not like the two individuals of a man and a horse.

This [is one point]. Next, it is characteristic of the intellect that, when it perceives things that have an earlier and later associated with them, it intellects the time with them necessarily—but that is not over a period of time but in an instant, where the intellect intellects the time in an instant. Its construction of the syllogism and the definition is unquestionably in a period of time; however, its conception of the conclusion and the thing defined is instantaneous.

The inability of the intellect to form concepts of things that are at the upper limit of being intelligible and abstracted from matter is not on account of something in those things themselves, nor on account of something innate to the intellect, but rather on account of the fact that the soul is distracted while in the body by the body. It needs the body for many things, but the body keeps it at a remove from the most noble of its perfections. The eye cannot bear to gaze at the Sun, certainly not on account of something in the Sun nor that it is not clearly visible, but rather on account of something about the natural makeup of the body [of the eye]. When this state of being immersed and impeded are removed from the soul we have, it will intellect these [extreme intelligibles] in the noblest, clearest, and most pleasurable ways. Our discussion here, however, concerns the soul only inasmuch as it is a soul, and that only inasmuch as it is associated with this matter. So we should not discuss the return of the soul when we are discussing nature, until we move on to the discipline of philosophy [i.e., metaphysics] and there investigate the things that are separate [from matter]. The investigation in the natural philosophy, however, is restricted to what is appropriate to natural things, and they are the things that bear relation to matter and motion.

So we say instead that the intellect forms concepts differently depending upon the existence of things. So with very strong things, the intellect may not be able to perceive them because they overwhelm it, and with very weakly existing things, like motion, time, and matter, the soul may find it difficult to form concepts of them because of their weak existence. As for privations, the intellect does not form concepts of them when it is actual in an absolute sense, because privation is perceived insofar as possession is not perceived, so whatever is perceived of privation as a privation and evil as an evil is something potential and an absence of a perfection. Any intellect that perceives it does so only because it bears some relation to it potentially. So the intellects in which nothing potential is mixed do not intellect nor form concepts of privation and evil as a privation and an evil, and there is nothing in existence that is an absolute evil.

Aquinas, *On the Soul*

Lectio 13 – Having explained in general terms how sense-faculties are related to their objects, the Philosopher now begins his examination of objects and faculties separately. This enquiry divides into two parts, of which one is concerned with the sense-objects, and the other, starting at 'It must be taken as a general rule', with the faculties. The first part again divides into (a) a discrimination of the proper or special sense-objects from the rest, and (b) at 'That of which there is sight', an examination of the special objects of each sense. As to (a) he first makes a division of the sense-objects, and then, at 'Now I call that the proper object,' explains this division piecemeal. Beginning then, he observes that before we decide what the senses themselves are we must discuss the objects of each sense; for objects are prior to faculties. Now the term sense-object is used in three ways, in one way incidentally, and in two ways essentially or absolutely; and of the latter we use one in referring to the special objects proper to each sense, and the other in referring to objects that-are common to more than one sense in all sentient beings. Then at 'Now I call that', he explains the members of the division, and first what he means by a special sense-object. He says that he means by this term what is perceived by one sense and by no other, and in respect of which the perceiving sense cannot err; thus it is proper to sight to know colour, to hearing to know sound, to taste to know flavour or savour. Touch, however, has several objects proper to itself— heat and moisture, cold and dryness, the heavy and the light, etc. Each sense judges the objects proper to itself and is not mistaken

about these, e.g. sight with regard to such and such a colour or hearing with regard to sound. But the senses can be deceived both about objects only incidentally sensible and about objects common to several senses., Thus sight would prove fallible were one to attempt to judge by sight what a coloured thing was or where it was; and hearing likewise if one tried to determine by hearing alone what was causing a sound. Such then are the special objects of each sense. Next, at 'Now the sense-objects', he says, touching the second member of the division, that the common sense-objects are five: movement, rest, number, shape and size. These are not proper to any one sense but are common to all; which we must not take to mean that all these are common to all the senses, but that some of them, i.e. number, movement and rest, are common to all. But touch and sight perceive all five. It is clear now what are the sense-objects that are such in themselves or absolutely. Then, at 'To be a sense-object incidentally', he takes the third member of the division. We might, he says, call Diarus or Socrates incidentally a sense-object because each happens to be white: that is sensed incidentally which happens to belong to what is sensed absolutely. It is accidental to the white thing, which is sensed absolutely, that it should be Diarus; hence Diarus is a sense-object incidentally. He does not, as such, act upon the sense at all. While it is true, however, that both common and special sense-objects are all absolutely or of themselves perceptible by sense, yet, strictly speaking, only the special sense-objects are directly perceived, for the very essence and definition of each sense consists in its being naturally fitted to be affected by some such special object proper to itself The nature of each faculty consists in its relation to its proper object. A difficulty arises here about the distinction between common and incidental sense-objects. For if the latter are only perceived in so far as the special objects are perceived, the same is true of the common sense-objects: the eye would never perceive size or shape if it did not perceive colour. It would seem then that the common objects themselves are incidental objects. Now there are some who base the distinction between common and incidental sense-objects upon two reasons. They say that (a) the common objects are proper to the 'common sense', as the special objects are to the particular senses; and (b) that the proper objects are inseparable from the common objects, but not from the incidental objects. But both answers are inept. The first is based on the fallacy that these common sense-objects are the special object of the 'common sense'. As we shall see later, the common sense is the faculty whereat the modifications affecting all the particular senses terminate; hence it cannot have as its special object anything, that is not an object of a particular sense. In fact, it is concerned with those modifications of the particular senses by their objects which these senses themselves cannot perceive; it is aware of these modifications themselves, and of the differences between the objects of each particular sense. It is by the common sense that we are aware of our own life, and that we can distinguish between the objects of different senses, e.g. the white and the sweet. Moreover, even granted that the common sense-objects were proper to the common sense, this would not prevent their being the incidental objects of the particular senses. For we are still studying the sense-objects in relation to the particular senses; the common sense has not yet been elucidated. As we shall see later, the special object of an interior faculty may happen to be only incidentally sensible. Nor is this strange; for even as regards the exterior senses, what is in itself and essentially perceptible by one of these exterior senses is incidentally perceptible by another; as sweetness is incidentally visible. The second reason is also inept. Whether or no the subject of a sensible quality pertains essentially to that quality makes no difference to the question whether the quality itself is an incidental sense-object. No one, for instance, would maintain that fire, which is the essential and proper subject of heat, was directly and in itself an object of touch. So we must look for another answer. We have seen that sensation is a being acted upon and altered in some way. Whatever, then, affects the faculty in, and so makes a difference to, its own proper reaction and modification has an intrinsic relation to that faculty and can be called a sense-object in itself or absolutely. But whatever makes no difference to the immediate modification of the faculty we call an incidental sense-object. Hence, the Philosopher says explicitly that the senses are not affected at all by the incidental object as such. Now an object may affect the faculty's immediate reaction in two ways. One way is with respect to the kind of agent causing this reaction; and in this way the immediate objects of sensation differentiate sense-experience, inasmuch as one such object is colour, another is sound, another white, another black, and so on. For the various kinds of stimulants of sensation are, in their actuality as such, precisely the special sense-objects themselves; and to them the sense-faculty (as a whole) is by nature adapted; so that precisely by their differences is sensation itself differentiated. On the other hand there are objects which differentiate sensation with respect, not to the kind of agent, but to the mode of its activity. For as sense-qualities affect the senses corporeally and locally, they do so in different ways, if they are qualities of large or small bodies or are diversely situated, i.e. near, or far, or together, or apart. And it is thus that the common sensibles differentiate sensation. Obviously, size and position vary for all the five senses. And not being related to sensation as variations in the immediate factors which bring the sense into

act, they do not properly differentiate the sense-faculties; they remain common to several faculties at once. Having seen how we should speak of the absolute or essential sense-objects, both common and-special, it remains to be seen how anything is a sense-object 'incidentally'. Now for an object to be a sense-object incidentally it must first be connected accidentally with an essential sense-object; as a man, for instance, may happen to be white, or a white thing happen to be sweet. Secondly, it must be perceived by the one who is sensing; if it were connected with the sense-object without itself being perceived, it could not be said to be sensed incidentally. But this implies that with respect to some cognitive faculty of the one sensing it, it is known, not incidentally, but absolutely. Now this latter faculty must be either another sense-faculty, or the intellect, or the cogitative faculty, or natural instinct. I say 'another sense-faculty', meaning that sweetness is incidentally visible inasmuch as a white thing seen is in fact sweet, the sweetness being directly perceptible by another sense, i.e. taste. But, speaking precisely, this is not in the fullest sense an incidental sense-object; it is incidental to the sense of sight, but it is essentially sensible. Now what is not perceived by any special sense is known by the intellect, if it be a universal; yet not anything knowable by intellect in sensible matter should be called a sense-object incidentally, but only what is at once intellectually apprehended as soon as a sense-experience occurs. Thus, as soon as I see anyone talking or moving himself my intellect tells me that he is alive; and I can say that I see him live. But if this apprehension is of something individual, as when, seeing this particular coloured thing, I perceive this particular man or beast, then the cogitative faculty (in the case of man at least) is at work, the power which is also called the 'particular reason' because it correlates individualised notions, just as the 'universal reason' correlates universal ideas. Nevertheless, this faculty belongs to sensitivity; for the sensitive power at its highest—in man, in whom sensitivity is joined to intelligence—has some share in the life of intellect. But the lower animals' awareness of individualised notions is called natural instinct, which comes into play when a sheep, e.g., recognises its offspring by sight, or sound, or something of that sort. Note, however, that the cogitative faculty differs from natural instinct. The former apprehends the individual thing as existing in a common nature, and this because it is united to intellect in one and the same subject. Hence it is aware of a man as this man, and this tree as this tree; whereas instinct is not aware of an individual thing as in a common nature, but only in so far as this individual thing is the term or principle of some action or passion. Thus a sheep knows this particular lamb, not as this lamb, but simply as something to be suckled; and it knows this grass just in so far as this grass is its food. Hence, other individual things which have no relation to its own actions or passions it does not apprehend at all by natural instinct. For the purpose of natural instinct in animals is to direct them in their actions and passions, so as to seek and avoid things according to the requirements of their nature.

Lectio 14 – Having distinguished the proper sense-objects from the common, and from those that are sensible incidentally, the Philosopher now treats of the proper object of each sense: first of the proper object of sight; then, at 'Now let us start', of that of hearing; then, at 'It is not so easy', of that of smell; then, at 'The tasteable', of that of taste; and lastly, at 'The same reasoning holds', of that of touch. As to sight, he discusses, first, its object, and then, at 'At present what is clear', how this object comes to be seen. Touching the object of sight, he does two things. First, he determines what is the visible, dividing it into two. secondly, he deals with either visible, at 'For the visible is colour'. He says then, first, that, the proper sense-object being that which each sense perceives of itself exclusively, the sense-object of which the special recipient is sight is the visible. Now in the visible two things are included; for both colour is a visible, and also something else, which can be described in speech, but has no proper name; which visible belongs to things which can be seen by night, such as glow-worms and certain fungi on oak-trees and the like, concerning which the course of this treatise will inform us more clearly as we gain a deeper understanding of the visible; but we have to start from colour which is the more obvious visible. Then, at 'For the visible', he begins to define both objects of sight: first colour and then, at 'Not all visible things'," that of which he says that it has no proper name. As to colour he does two things: first, he shows what colour has to do with visibility; secondly, at 'There is, accordingly, something transparent' he settles what is required for colour to be seen. First of all, then, he says that, colour being visible, it is visible of itself, for colour as such is essentially visible. 'Essentially' is said in two ways. In one way, when the predicate of a proposition falls within the definition of the subject, e.g. 'man is an animal'; for animal enters into the definition of man. And since that which falls within the definition of anything is in some way the cause of it, in cases such as these the predicate is said to be the cause of the subject. In another way, on the contrary, when the subject of the proposition falls within the definition of the predicate, as when it is said that a nose is snub, or a

number is even; for snubness is nothing but a quality of a nose, and evenness of a number which can be halved; and in these cases the subject is a cause of the predicate. Now colour is essentially visible in this second manner, not in the first; for visibility is a quality, as being snub is a quality of a nose. And this is why he says that colour is visible 'essentially', but 'not by definition'; that is to say, not because visibility is placed in its definition, but because it possesses of itself the reason why it should be visible, as a subject possesses in itself the reason for its own peculiar qualities. Which he proves by this, that every colour as such is able to affect what is actually diaphanous. The diaphanous is the same as the transparent (e.g. air or water), and colour has it in its nature to actualise further an actual transparency. And from this, that it affects the actually transparent, it is visible; whence it follows that colour is of its nature visible. And since the transparent is brought to its act only by light, it follows that colour is not visible without light. And therefore before explaining how colour is seen, we must discuss light. Then, at 'There is, accordingly', he discusses those things without which colour cannot be seen, namely the transparent and light; and this in three sections. First, he explains the transparent. Secondly, at 'Light is', he treats of the transparent's actuality, i.e. light. Thirdly, he shows how the transparent is receptive of colour, at 'Now that only can receive colour'. To begin with, therefore, he says that if colour is that which of its nature affects the transparent, the latter must be, and in fact is, that which has no intrinsic colour to make it visible of itself, but is receptive of colour from without in a way which renders it somehow visible. Examples of the transparent are air and water and many solid bodies, such as certain jewels and glass. Now, whereas other accidents pertaining to the elements or to bodies constituted from them, are in these bodies on account of the nature of those elements (such as heat and cold, weight and lightness, etc.), transparency does not belong to the nature of air or water as such, but is consequent upon some quality common, not only to air and water, which are corruptible bodies, but also to the celestial bodies, which are perpetual and incorruptible. For at least some of the celestial bodies are manifestly transparent. We should not be able to see the fixed stars of the eighth sphere unless the lower spheres of the planets were transparent or diaphanous. Hence it is evident that to be transparent is not a property consequent on the nature of air or water, but of some more generic nature, in which the cause of transparency is to be found, as we shall see later. Next, at 'Light etc.', he explains light, first stating the truth, then dismissing an error. He says, to begin with, that light is the act of the transparent as such. For it is evident that neither air nor water nor anything of that sort is actually transparent unless it is luminous. Of itself the transparent is in potency to both light and darkness (the latter being a privation of light) as primary matter is in potency both to form and the privation of form. Now light is to the transparent as colour is to a body of definite dimensions: each is the act and form of that which receives it. And on this account he says that light is the colour, as it were, of the transparent, in virtue of which the transparent is made actually so by some light-giving body, such as fire, or anything else of that kind, or by a celestial body. For to be full of light and to communicate it is common to fire and to celestial bodies, just as to be diaphanous is common to air and water and the celestial bodies. Then, at 'We have then indicated' he rejects a false opinion on light; and this in two stages. First, he shows that light is not a body; then he refutes an objection brought against the arguments which prove that fight is not a body, at 'Empedocles... was wrong'. As to the first point he does three things. (a) He states his own view, saying that, once it is clear what the transparent is, and what light is, it is evident that light is neither fire (as some have said, positing three kinds of fire, the combustible, and flame, and light); nor a body at all, or anything flowing from a body, as Democritus supposed, asserting that light consisted of atomic particles emanating from luminous bodies. If there were these emanations from bodies, they would themselves be bodies, or something corporeal, and light would thus be nothing other than fire, or something material of that sort, present in the diaphanous; which is the same as to say that light is a body or an emanation from a body. (b) At 'For it is impossible', he proves his own hypothesis thus. It is impossible for two bodies to be in one place at one time. If therefore light were a body, it could not co-exist with a diaphanous body; but this is false; therefore light is not a body. (c) At 'Light seems' he shows that light does co-exist with the diaphanous body. For contraries exist in one and the same subject. But light and darkness are contraries in the manner in which a quality and its privation are contraries, as is stated in the Metaphysics, Book X. Obviously, darkness is a privation of this quality, i.e. of light in the diaphanous body-which is therefore the subject of darkness. Hence too, the presence of this quality is light. Therefore light co-exists with the diaphanous. Then at 'Empedocles... was wrong' he refutes an answer to one argument which might be urged against those who hold that light is a body. For it is possible to argue thus against them: if light were a body, illumination ought to be a local motion of light passing through the transparent; but no local movement of any body can be sudden or instantaneous; therefore, illumination would be, not instantaneous but successive, according to this view. Of which the contrary is a fact of

experience; for in the very instant in which a luminous body becomes present, the transparent it illuminated all at once, not part after part. So Empedocles, and all others of the same opinion, erred in saying that light was borne along by local motion, as a body is; and that it spread out successively through space, which is the medium between the earth and its envelope, i.e. the sky; and that this successive motion escapes our observation, so that the whole of space seems to us to be illuminated simultaneously. For this assertion is irrational. The illumination of the transparent simply and solely presupposes the placing of a luminous body over against the one illumined, with no intervening obstacle. Again, it contradicts appearances. One might indeed allow that successive local motion over a small space could escape our notice; but that a successive movement of light from the eastern to the western horizon should escape our notice is so great an improbability as to appear quite impossible. But as the subject matter under discussion is threefold, i.e. the nature of light, and of transparency, and the necessity of light for seeing, we must take these three questions one by one. On the nature of light various opinions have been held. Some, as we have seen, held that light was a body; being led to this by certain expressions used in speaking of light. For instance, we are accustomed to say that a ray 'passes through' the air, that it is 'thrown back', that rays 'intersect', and so forth; which all seem to imply something corporeal. But this theory is groundless, as the arguments here adduced of Aristotle show, to which others might easily be added. Thus it is hard to see how a body could be suddenly multiplied over the whole hemisphere, or come into existence or vanish, as light does; nor how the mere intervention of an opaque body should extinguish light in any part of a transparent body if light, itself were a body. To speak of the motion or rebounding of light is to use metaphors, as when we speak of heat 'proceeding into' things that are being heated or being 'thrown back' when it meets an obstacle. Then there are those who maintain, on the contrary, that light is spiritual in nature. Otherwise, they say, why should we use the term 'light' in speaking of intellectual things? For we say that intellectual things possess a certain intelligible 'light'. But this also is inadmissible. For it is impossible that any spiritual or intelligible nature should fall within the apprehension of the senses; whose power, being essentially embodied, cannot acquire knowledge of any but bodily things. But if anyone should say that there is a spiritual 'light' other than the light that is sense-perceived, we need not quarrel with him; so long as he admits that the light which is sense-perceived is not spiritual in nature. For there is no reason why quite different things should not have the same name. The reason, in fact, why we employ 'light' and other words referring to vision in matters concerning the intellect is that the sense of sight has a special dignity; it is more spiritual and more subtle than any other sense. This is evident in two ways. First, from the object of sight. For objects fall under sight in virtue of properties which earthly bodies have in common with the heavenly bodies. On the other hand, touch is receptive of properties which are proper to the elements (such as heat and cold and the like); and taste and smell perceive properties that pertain to compound bodies, according as these are variously compounded of heat and cold, moisture and dryness; sound, again, is due to local movement which, indeed, is also common to earthly and heavenly bodies, but which, in the case of the cause of sound; is a different kind of movement from that of the heavenly bodies, according to the opinion of Aristotle. Hence, from the very nature of the object it would appear that sight is the highest of the senses; with hearing nearest to it, and the others still more remote from its dignity. The same point will appear if we consider the way in which the sense of sight is exercised. In the other senses what is spiritual in their exercise is always accompanied by a material change. I mean by 'material change' what happens when a quality is received by a subject according to the material mode A the subject's own existence, as e.g. when anything is cooled, or heated, or moved about in space; whereas by a 'spiritual change' I mean, here, what happens when the likeness of an object is received in the sense-organ, or in the medium between object and organ, as a form, causing knowledge, and not merely as a form in matter. For there is a difference between the mode of being which a sensible form has in the senses and that which it has in the thing sensed. Now in the case of touching and tasting (which is a kind of touching) it is clear that a material change occurs: the organ itself grows hot or cold by contact with a hot or cold object; there is not merely a spiritual change. So too the exercise of smell involves a sort of vaporous exhalation; and that of sound involves movement in space. But seeing involves only a spiritual change-hence its maximum spirituality; with hearing as the next in this order. These two senses are therefore the most spiritual, and are the only ones under our control. Hence the use we make of what refers to them—and especially of what refers to sight—in speaking of intellectual objects and operations. Then again some have simply identified light with the manifestation of colour. But this is patently untrue in the case of things that shine by night, their colour, nevertheless, remaining obscure. Others, on the other hand, have said that light was the substantial form of the sun, and that the brightness proceeding therefrom (in the form of colours in the air) had the sort of being that belongs to objects causing knowledge as such. But both these propositions are false. The former, because

no substantial form is in and of itself an object of sense perception; it can only be intellectually apprehended. And if it is said that what the sense sees in the sun is not light itself but the splendour of light, we need not dispute about names, provided only it be granted that what we call light, i.e. the sight-perceived thing, is not a substantial form. And the latter proposition too is false; because whatever simply has the being of a thing causing knowledge does not, as such, cause material chance; but the rays from the heavenly bodies do in fact materially affect all things on earth. Hence our own conclusion is that, just as the corporeal elements have certain active qualities through which they affect things materially, so light is the active quality of the heavenly bodies; by their light these bodies are active; and this light is in the third species of quality, like heat. But it differs from heat in this: that light is a quality of the primary change-effecting body, which has no contrary: therefore light has no contrary: whereas there, is a contrary to heat. And because there is no positive contrary to light, there is no place for a contrary disposition in its recipient: therefore, too, its matter, i.e. the transparent body, is always as such immediately disposed to its form. That is why illumination occurs instantaneously, whereas what can become hot only becomes so by degrees. Now this participation or effect of light in a diaphanum is called 'luminosity'. And if it comes about in a direct line to the lightened body, it is called a 'ray'; but if it is caused by the reflection of a ray upon a light-receiving body, it is called 'splendour'. But luminosity is the common name for every effect of light in the diaphanous. So much being admitted as to the nature of light, we can easily understand why certain bodies are always actually lucent, whilst others are diaphanous, and others opaque. Because light is a quality of the primary change-effecting body, which is the most perfect and least material of bodies, those among other bodies which are the most formal and the most mobile to actualisation are always actually lucent; and the next in this order are diaphanous; whilst those that are extremely material, being neither luminous of themselves nor receptive of light, are opaque. One may see this in the elements: fire is lucent by nature, though its light does not appear except in other things. Air and water, being more material, are diaphanous; whilst earth, the most material of all, is opaque. With regard to the third point (the necessity of light for seeing), note that it has been the opinion of some that not merely seeing, but the object of seeing, i.e. colour as such, presupposed the presence of light; that colour as such had no power to affect a transparent medium; that it does this only through light. An indication of this was, they said, that one who stands in the shadow can see what is in the light, but one who stands in the light cannot see what is -in shadow. The cause of this fact, they said, lay in a correspondence between sight and its object: as seeing is a single act, so it must bear on an object formally single; which would not be the case if colour were visible of itself—not in virtue of light—and light also were visible of itself. Now this view is clearly contrary to what Aristotle says here, 'and... has in itself the cause of being visible'; hence, following his opinion, I say that light is necessary for seeing, not because of colour, in that it actualises colours (which some say are in only potency so long as they are in darkness), but because of the transparent medium which light renders actual, as the text states. And in proof of this, note that every form is, as such, a principle of effects resembling itself colour, being a form, has therefore of itself the power to impress its likeness on the medium. But note also that there is this difference between the form with a complete, and the form with an incomplete, power to act, that the former is able not merely to impress its likeness on matter, but even to dispose matter to fit it for this likeness; which is beyond the power of the latter. Now the active power of colour is of the latter sort; for it is, in fact, only a kind of light somehow dimmed by admixture of opaque matter. Hence it lacks the power to render the medium fully disposed to receive colour; but this pure light can do. Whence it is also clear that, as light is, in a certain way, the very substance of colour, all visible objects as such share in the same nature:, nor does colour require to be made visible by some other, extrinsic, light. That colours in light are visible to one standing in the shade is due to the medium's having been sufficiently illumined.

Lectio 15 – After treating of colour and the transparent medium and luminosity, the Philosopher now proceeds to explain how the medium is related to colour. It is clear, from the foregoing, that the transparent medium is receptive of colour; for colour, we have seen, acts upon it. Now what is receptive of colour must itself be colourless, as what receives sound must be soundless; for nothing receives what it already has. The transparent medium is therefore colourless. But, as bodies are visible by their colours, the transparent medium must itself be invisible. Yet since one and the same power apprehends contrary qualities, it follows that sight, which apprehends light, also apprehends darkness. Hence, although the transparent medium of itself possesses neither light nor colour, being receptive of both, and is thus not of itself visible in the way that things bright or coloured are visible, it can, all the same, be called visible in the same sort of way as dark things and scarcely visible things are so called. The diaphanum is therefore a kind of darkness, so long

as it is not actually but only potentially transparent: the same thing is the subject, sometimes of darkness, sometimes of light. Thus the diaphanum, while it lacks luminosity and is only potentially transparent, is in a state of darkness. Then at 'Not all', having decided about colour, which is made visible by light, he reaches a conclusion about that other visible object of which he said above that it had no proper name. He observes that not all things depend on light for being seen, but only the colour that is proper to each particular thing. Some things, e.g. certain animals that appear fiery and lucent in the dark, are not visible in the light, but only in darkness. There are many such things, including the fungi of oaks, the horn of certain beasts and heads of certain fish, and some animals' scales and eyes. But while all these things are visible in the dark, the colour proper to each is not seen in the dark. The things are seen both in light and in darkness; but in darkness only as bright objects, in light as coloured objects. The reason why they are seen shining in the darkness is another matter. Aristotle only mentions the fact incidentally, in order to show the relation of the visible to luminosity. This, however, seems to be the reason for their being visible in the dark, that such things have in their constitution something of light, inasmuch as the brightness of fire and the transparency of air and water is not entirely smothered in them by the opacity of earth. But having only a small amount of light, their brightness is obscured in the presence of a greater light. Hence in the light they appear not as bright, but only as coloured. The light in their constitution is so weak that it is unable perfectly to actualise the potentially transparent medium to receive the full effect of the colours which by nature it is fitted to receive. Hence, by this light neither their own colour, nor that of other things, is seen: but only their brightness. For brightness, being a more effective agent upon the medium than colour, and in itself more visible, can be seen with less alteration of the medium than colour requires. Next, at 'At present what is clear', he explains how colour actually affects sight, first pointing out what this necessarily presupposes, and then, at 'The same account holds', indicating a like necessary condition in the case of the other senses. As to the former point, he first decides what is the truth of the matter, and then at 'Democritus etc.', sets aside an error. First, then, he says that we are now clear that what is seen in light is colour, and that colour is invisible without light; and this because, as has been explained, colour of its nature acts upon a transparent medium, and it does this in virtue of light, which is the latter's actuality. Hence light is necessary if colour is to be seen. An indication of this is the fact that if a coloured body is placed upon the organ of sight it cannot be seen; for then there remains no transparent medium to be affected by the colour. The pupil of the eye is indeed some such medium, but, so long as the coloured body remains placed upon it, it lacks actual transparency. There has to be a medium, say air or something of the kind, which, being actualised by colour, itself acts upon the organ of sight as upon a body continuous with itself, for bodies only affect one another through actual contact. Then at 'Democritus etc.', he sets aside an erroneous view. Democritus, he says, was wrong in thinking that if the medium between the eye and the thing seen were a vacuum, any object, however small, would be visible at any distance, e.g. an ant in the sky. This cannot be. For if anything is to be seen it must actually affect the organ of sight. Now it has been shown that this organ as such is not affected by an immediate object—such as an object placed upon the eye. So there must be a medium between organ and object. But a vacuum is not a medium; it cannot receive or transmit effects from the object. Hence through a vacuum nothing would be seen at all. Democritus went wrong because he thought that the reason why distance diminishes visibility was that the medium is of itself an impediment to the action of the visible object upon sight. But it is not so. The transparent medium as such is not in the least incompatible with luminosity or colour; on the contrary, it is proximately disposed to their reception; a sign of which is that it is illumined or coloured instantaneously. The real reason why distance diminishes visibility, is that everything seen is seen within the angle of a triangle, or rather pyramid, whose base is the object seen and apex in the eye that sees. It makes no difference whether seeing takes place by a movement from the eye outwards, so that the lines enclosing the triangle or pyramid run from the eye to the object, or e converso, so long as seeing does involve this triangular or pyramidal figure; which is necessary because, since the object is larger than the pupil of the eye, its effect upon the medium has to be scaled down gradually until it reaches the eye. And, obviously, the longer are the sides of a triangle or pyramid the smaller is the angle at the apex, provided that the base remains the same. The further away, then, is the object, the less does it appear—until at a certain distance it cannot be seen at all. Next, at 'But fire', he explains how fire and bright bodies are seen—which are visible not only, like coloured objects, in the light, but even in the dark. There is a necessary reason for this, namely that fire contains enough light to actualise perfectly the transparent medium, so that both itself and other things become visible. Nor does its light fade out in the presence of a greater light, as does that of the objects mentioned above. Then, at 'The same account', he shows how the case of the other senses is similar to sight. No sound or odour, e.g., is perceived if there is immediate contact with the organ in question. There must be a medium affected by sound or odour,

which itself then. affects our sense of hearing or of smell. A sounding or odorous body placed upon the organ is not perceived as such. The same is true even of touch and taste, though, for a reason to be given later, this is less evident. Finally, at 'The medium of sound' he states what is the medium in hearing and smelling. That of hearing is air, and that of smelling is something common to air and water—just as both of these provide a medium for colour in so far as each is a transparency. There is indeed no name for the quality in air and water which provides the medium for odour; but it certainly is not transparency. And that both air and water are conductors of smell he shows from the fact that marine animals have a sense of smell. Man, however, and other animals that walk and breathe, only smell by breathing; which proves that air is the medium of smell. This fact will be explained later.

Nicholas of Autrecourt, *Universal Treatise*

It is therefore probable that whatever appears is true; that is, what is clear and evident in a full light. For otherwise the intellect would be sure of nothing, since the intellect can claim to be sure only of what is experienced directly or is reasoned to as a result of experience (as with those things which follow as a natural result of experience). This is obvious, for the intellect is sure of nothing insofar as it is in darkness, but insofar as it is in the light. Therefore what the intellect is certain of must be either the light itself (as our experiences are) or what is consequent upon the light (as what we reason to as a natural result of our experiences or by way of abstraction from our experiences).

Considering a man who says he has certainty, I ask him further whether or not he has some light or some appearance in which light or appearance he says he has certainty. If not, he is therefore in darkness and speaks like a blind man. If there is some light or appearance, then either what he says he is certain of is the light itself or the light is [part] of it. Then it is always experienced in itself or in its light, or what he says he is certain about is consequent upon, or related to, [what is so experienced]. For, if the light itself did not have some relationship to what he says he is sure of, it would be, as it were, completely in darkness in regard to it; and then, like a blind man, he would not be sure of it. If it has a relationship, which one ought to admit, this relationship might be a contingent one, indifferent to whether [the relationship] exists or not. But then he will not be able to say that he is certain through that light or appearance, because he could not say he was surer of its existence than of its nonexistence. Thus it must have a necessary relationship. And, if this is the case, [what he says he is sure of] can be reasoned to by means of a conclusion, for, if something is present, all things necessarily consequent upon it seem to be present also. As a consequence it is true that no one can claim certainty about something unless he has the light providing either it or what it is necessarily consequent upon. Because of this proposition, I have said elsewhere that no one can say that in a body, besides the three dimensions, there is a reality which is the subject of them, as those say who posit that quantity is distinct from material substance. The reason is that that reality does not provide the intellect with any light in which the existence of that reality is experienced. For we have not seen it or heard it; nor can the existence of such a reality be reasoned to from what we see or from what we sense in any other way whatever, as has been said elsewhere.

According to this teaching, then, it can with probability be said that, if a man can say he is certain of something, what appears (properly speaking and in the final analysis) is true. Let us express this rule in other words: every act of affirmation which is formulated in a full light, in so far as man can have a full light, is true. For every act measuring up to its true norm is true. And an act of affirmation formulated in a full light measures up to its true norm, that is, the full light. For we can state nothing with certainty unless in relation to the light or the appearance which we have. For these have the nature of a measure and principle, as has been sufficiently seen above. As has been said above, it would not be valid to say that the full light does not of itself have the nature of a measure, but [only] if three things concur, that is, the proper disposition of the organ and of the medium, and the proper distance of the object. For I ask two things of one who says this. First, how is he sure that they are required? He will not be able to give a true means [of knowing] other than an appearance or its light, and thus his denial of the statement will involve its admission. Secondly, I ask the one who says he has certainty, whether he knows that those three things do concur, [that is,] that his faculty is properly disposed, etc. He cannot allege a true means [of knowing] except that it appears so to him. Therefore he will always have to fall back on what he has denied, namely, that a full appearance, without any reservation, is always true, and that an act of affirmation based on it is always true.

We have used the expression "full light" because a light which is not full does not have the nature of a measure. Hence they argue frivolously who say: "In sleep it appears that I am running through the camp,

or that I am in heaven, and yet this is not so." I answer: "It did not appear to you with a full appearance, for a full appearance of the truth of this statement is an appearance through the external senses when you see the movement through sight."

But it should be known, because of certain other matters, that sometimes a thing is said to be seen in its own light, and sometimes in the light of its image, as when a man is seen in a mirror. Now I say that every act of affirmation which is based on light and does not exceed it is true. Therefore, when the sun is seen, some say that sense is deceived because [the sun] is larger than the whole earth and yet seems to have a size of two feet [around]. It is amazing that they talk so. If they were to think over carefully what they are saying they would see that he [sic] is speaking in darkness, or else they would agree with us. For they say that the whole sun is larger than the whole earth, and they say that what they see is in its appearance only one foot [across]. How will the fact that it appears in its entirety and the fact that it appears to be only one foot [across] be reconciled? I say, then, that it is seen by us in the light of its image. Thus we see the one image which is the image of the sun; when this has been seen, the sun is said, after a fashion, to be seen. And in that [image] one part is not represented more than another. Hence the sun's extension is represented there only by way of resemblance in shape, substance, and light; it is not represented there by way of a quantity equal [to the original]. Some want to use this fact as the basis of a specious argument proving that quantity is really distinct from substance and shape, but I forego a rebuttal for now. It is sufficient for me at present that there is a true act of affirmation which refers to an image smaller than the whole earth.

The same answer would be given concerning a stick appearing broken in the water. I say that the appearance has to do with an image, which is of the same nature at is appears [to be]. I would say the same concerning a river-bank which, to a man in a ship, appears to move. Concerning the man with a fever to whom sweet things seem bitter, it can be said, as above, that this is due to certain really bitter things which are present in the organ of taste. So these objections have little force against my contention. Rather [what I have said] has much more force because, according to what was said concerning the light of an image, it would follow that no one could speak of the true subjective existence of whiteness or anything else. For he cannot say [anything about it] except according to its appearance, [and] it will now be said that that appearance terminates at the image of the thing and not at something subjectively existing in a thing outside. It must be said, of course, that it is certain that when sight sees whiteness it sees something. Its appearance vouches for this; and that it is outside the eye and in such and such a place. I grant that all these things are true.

Now, when vision does not change, no matter where it turns or what its state, and [whiteness] appears to it, it imposes that name [whiteness] and says that true whiteness is there, possessing a stable or subjective existence. When this is not the case, it imposes the name and calls that thing an image, as when a man is seen in a mirror, or when a man sees the river-bank move but would not see it move if he were in another spot, provided he saw it most fully. But it is somehow not sure that there is any difference between the image and what it calls a fixed thing; indeed, from its appearance, there is simply a numerical difference. (In the case of touch, indeed, there does not seem to be any reason for doubting, for it does not seem to be concerned sometimes with an image, but always with a fixed thing.)

2. Light, Vision, and Colour in Optical Theories

Texts:

1. Plato, *Timaeus*. Transl. Waterfield (Oxford, 2008), 35-37 and 65-67.
2. Aristotle, *Meteorologica*, book 3, chapters 2, 4 and 5. Transl. Webster (Princeton, 1991), 56-57 and 58-64.
3. Ibn al-Haytham, *Optics*, book 1, chapter 3, excerpts. Transl. Sabra (London 1989), 13-19.
4. Robert Grosseteste, *On Colour*. Transl. Dinkova-Bruun *et al.* (Toronto, 2013), 17-19.
5. Robert Grosseteste, *On the Rainbow,* Transl. Sparavigna ("On the Raibow," 2013), 108-111.
6. John Peckham, *Perspectiva communis*, part 2, excerpts. Transl. Lindberg (Bloomington 1965), 107-112

Plato, *Timaeus*

Light – The first of the organs they constructed were the light-bearing eyes, and the reason they attached the eyes to the face was as follows. They found a way to make a distinct stuff out of that portion of fire which has the ability to shed gentle light without burning, and to make it the property of each passing day. Then they made the pure fire within us, which is naturally akin to this daylight, flow through the eyes, and they compressed the whole of the eyes, but especially the central part, until they were smooth and dense, so that they would block everything that was more coarse and let only something with this kind of purity filter through. So whenever the ray that flows through the eyes issues forth into surrounding daylight, like meets with like and coalesces with it, until a single, undifferentiated stuff is formed, in alignment with the direction of the eyes, wherever the fire from inside strikes and pushes up against an external object. The similarity between the fire from within and the fire outside means that the stuff is completely homogeneous, and whenever it touches or is touched by anything else, it transmits the object's impulses right through itself and all the way up to the soul, and the result is the perception we call 'seeing'.

At nightfall, however, with the departure of its cognate fire, the visual ray is interrupted. It issues forth, but, encountering something dissimilar to itself, fades and dies out, since it can no longer attach itself to the fireless air adjacent to it.

The upshot is that it not only stops seeing, but also encourages sleep. For the internal fire, which gets trapped inside by the closure of the eyelids (the gods' way of protecting the organ of sight), disperses and smooths out any internal impulses, and the result of this smoothness is a state of quiet. When the state of quiet is profound, the sleep that ensues is almost dreamless, but when some relatively large impulses remain trapped inside, they produce images whose nature and number depend on the nature and location of the movements; and although these images are internal copies, when awake we recall them as events that occurred outside us.

It should now be easy to understand what happens in the formation of images by mirrors or any other reflective surface. As a result of the interaction between the fire from inside and the fire from outside, and because a single, though much-distorted, substance is formed on each occasion by the surface, things necessarily appear as they do. When the fire from your face coalesces with the fire from my organ of sight on something that is smooth and bright, left appears to be right, because the opposite parts of the visual ray make contact with the opposite parts of your face, contrary to the way they usually impact on each other. On the other hand, right appears as right and left as left whenever light changes sides as it coalesces with the other light, and this happens when the mirror's surface is curved up on either side, so that the right side of the visual ray is deflected over to the left, and vice versa. But when just such a mirror is turned until it is vertical in relation to the face, it makes everything appear upside down, since the bottom of the ray is deflected to the top and the top to the bottom.

Colours – The fourth and final kind of perception contains so many varieties that we must divide it up. We call them all 'colours', and each of them is a flame that flows from individual bodies and whose particles, being compatible with the organ of sight, produce vision. I've already explained how sight occurs, but no more than that, and so now it makes excellent sense for us to cover colours. The following account would seem to be reasonable. The particles that travel from external objects and encounter the visual ray are of various sizes — some smaller, some larger, and some the same size as the particles of the visual ray itself.

Those that are the same size are imperceptible — in fact, they are precisely those things that we call 'transparent'. Those that are larger contract the visual ray, while the smaller ones expand it, and so these larger and smaller particles are close kin to the hot and cold particles that act on flesh, and to the astringent particles and also those heating ones we called 'spicy' that act on the tongue. The particles we call 'black' and 'white', then, are the same as those qualities, but in a different category, and they appear different from each other for the reasons given. And so we should use the names accordingly: 'white' is what expands the visual ray, and 'black' is the opposite.

When a different kind of fire, with a faster movement, strikes the visual ray and expands it all the way up to the eyes, it forces apart and decomposes the actual openings in the eyes, and expresses from them a flood of mixed fire and water, which we call 'weeping'. Since this fast-moving force is itself fire, when it meets fire from the opposite direction — the one leaping out from the eyes like a flash of lightning, and the other forcing its way in and being extinguished in the moisture — the ensuing turmoil creates all sorts of colours, and we call the experience 'dazzling', and what causes it 'bright' and 'shiny'.

There is also a kind of fire which is intermediate between these last two. It reaches the moisture of the eyes and blends with it, but it doesn't dazzle; and to the gleam of the fire through the moisture with which it is mixed, which produces the colour of blood, we give the name 'red'. When bright is mixed with red and white, the result is orange-yellow, but it would be foolish to try to state the precise proportions of the mixture, even if they were knowable, because one couldn't, with any degree of plausibility, come up with either a proof or a likely account of them.

Red mixed with black and white makes magenta, and violet is the result when this mixture is further burnt and more black is mixed in. The mixture of orange-yellow and grey produces yellow ochre, while grey is a blend of black and white. Yellow comes from the mixture of white and orange-yellow. The combination of bright and white, steeped in deep black, produces dark blue; dark blue mixed with white makes light blue; and yellow ochre blended with black makes green.

As for the rest, it should be more or less clear from these examples what mixtures we must say they are equivalent to, if we're to preserve our likely story. But if one were to investigate these matters by actually putting them to the test, he would be displaying ignorance of the difference between human beings and gods. It is a divine matter to possess sufficient knowledge, and at the same time sufficient competence, to mix a plurality into a oneness, and conversely to break a oneness up into a plurality; there is not now nor will there ever be any human being who is up to either of these tasks.

Aristotle, *Meteorologica*

Book 3, chapter 2 – Let us now explain the nature and cause of halo, rainbow, mock suns, and rods, since the same causes account for them all.

We must first describe the phenomena and the circumstances in which each of them occurs. The halo often appears as a complete circle: it is seen round the sun and the moon and bright stars, by night as well as by day, and at midday or in the afternoon, more rarely about sunrise or sunset.

The rainbow never forms a full circle, nor any segment greater than a semicircle. At sunset and sunrise the circle is smallest and the segment largest: as the sun rises higher the circle is larger and the segment smaller. After the autumn equinox in the shorter days it is seen at every hour of the day, in the summer not about midday. There are never more than two rainbows at one time. Each of them is three-coloured; the colours are the same in both and their number is the same, but in the outer rainbow they are fainter and their position is reversed. In the inner rainbow the first and largest band is red; in the outer rainbow the band that is nearest to this one and smallest is of the same colour: the other bands correspond on the same principle. These are almost the only colours which painters cannot manufacture; for there are colours which they create by mixing, but no mixing will give red, green, or purple. Those are the colours of the rainbow, though between the red and the green an orange colour is often seen.

Mock suns and rods are always seen by the side of the sun, not above or below it nor in the opposite quarter of the sky. They are not seen at night but always in the neighbourhood of the sun, either as it is rising or setting but more commonly towards sunset. They have scarcely ever appeared when the sun was on the meridian, though this once happened in Bosporus where two mock suns rose with the sun and followed it all through the day till sunset.

These are the facts about each of these phenomena: the cause of them all is the same, for they are all reflections. But they differ in the manner of the reflection and in the reflecting surfaces and according as the reflection to the sun or some other bright object is.

The rainbow is seen by day, and it was formerly thought that it never appeared by night as a moon rainbow. This opinion was due to the rarity of the occurrence: it was not observed; for though it does happen it does so rarely. The reason is that the colours are not so easy to see in the dark and that many other conditions must coincide, and all that in a single day in the month. For if there is to be one it must be at full moon, and then as the moon is either rising or setting. So we have only met with two instances of a moon rainbow in more than fifty years.

We must accept from the theory of optics the fact that sight is reflected from air and any object with a smooth surface just as it is from water; also that in some mirrors the shapes of things are reflected, in others only their colours. Of the latter kind are those mirrors which are so small as to be indivisible for sense. It is impossible that the shape of a thing should be reflected in them; for if it is the mirror will seem divisible—for every shape is at once a shape and divisible. But since something must be reflected in them and shape cannot be, it remains that colour alone should be reflected. The colour of a bright object sometimes appears bright in the reflection, but it sometimes, either owing to the admixture of the colour of the mirror or to weakness of sight, gives rise to the appearance of another colour.

However, we must accept the account we have given of these things in the investigation of sensation, and take some things for granted while we explain others.

Book 3, chapter 4 – We have already stated that the rainbow is a reflection: we have now to explain what sort of reflection it is, to describe its various concomitants, and to assign their causes.

Sight is reflected from all smooth surfaces, such as are air and water among others. Air must be condensed if it is to act as a mirror, though it often gives a reflection even uncondensed when the sight is weak. Such was the case of a man whose sight was faint and indistinct. He always saw an image in front of him and facing him as he walked. This was because his sight was reflected back to him. Its morbid condition made it so weak and delicate that the air close by acted as a mirror, just as distant and condensed air normally does, and his sight could not push it back. That is why promontories in the sea loom when there is a south-east wind, and everything seems bigger, and in a mist, too, things seem bigger—as the sun and the stars seem bigger when rising and setting than on the meridian. But things are best reflected from water, and even in process of formation it is a better mirror than air; for each of the particles, the union of which constitutes a raindrop, is necessarily a better mirror than mist. Now it is obvious and has already been stated that a mirror of this kind renders the colour of an object only, but not its shape. Hence it follows that when it is on the point of raining and the air in the clouds is in process of forming into raindrops but the rain is not yet actually there, if the sun is opposite, or any other object bright enough to make the cloud a mirror and cause the sight to be reflected to the object, then the reflection must render the colour of the object without its shape. Since each of the mirrors is so small as to be invisible and what we see is the continuous magnitude made up of them all, the reflection necessarily gives us a continuous magnitude made up of one colour, each of the mirrors contributing the same colour to the whole. Hence since these conditions are realizable there will be an appearance due to reflection whenever the sun and the cloud are related in the way described and we are between them. But these are just the conditions under which the rainbow appears. So it is clear that the rainbow is a reflection of sight to the sun.

So the rainbow always appears opposite the sun whereas the halo is round it. They are both reflections, but the rainbow is distinguished by the variety of its colours. The reflection in the one case is from water which is dark and from a distance; in the other from air which is nearer and lighter in nature. Bright light through a dark medium or on a dark surface (it makes no difference) looks red. We can see how red the flame of green wood is: this is because so much smoke is mixed with the bright white firelight: so, too, the sun appears red through smoke and mist. That is why in the rainbow reflection the outer circumference is red (the reflection being from small particles of water), but not in the case of the halo. The other colours shall be explained later. Again, a condensation of this kind cannot persist in the neighbourhood of the sun itself: it must either turn to rain or be dissolved; but opposite to the sun there is an interval during which the water is formed. If there were not this distinction haloes would be coloured like the rainbow. Actually no complete or circular halo presents this appearance, only small and fragmentary ones called 'rods'. But if

a haze due to water or any other dark substance formed there we should have had, as we maintain, a complete rainbow like that which we do find round lamps. A rainbow appears round these in winter, generally with southerly winds. Persons whose eyes are moist see it most clearly because their sight is weak and easily reflected. It is due to the moistness of the air and the soot which the flame gives off and which mixes with the air; for a mirror is then formed actually because of the blackness—for soot is smoky. The light of the lamp appears as a circle which is not white but purple. It shows the colours of the rainbow; but because the sight that is reflected is too weak and the mirror too dark, red is absent. The rainbow that is seen when oars are raised out of the sea involves the same relative positions as that in the sky, but its colour is more like that round the lamps, being purple rather than red. The reflection is from very small particles continuous with one another, and in this case the particles are fully formed water. We get a rainbow, too, if a man sprinkles fine drops in a room turned to the sun so that the sun is shining in part of the room and throwing a shadow in the rest. Then if one man sprinkles in the room, another, standing outside, sees a rainbow where the sun's rays cease and make the shadow. Its nature and colour is like that from the oars and its cause is the same, for the sprinkling hand corresponds to the oar.

That the colours of the rainbow are those we described and how the other colours come to appear in it will be clear from the following considerations. We must recognize, as we have said, and lay down first, that white colour on a black surface or seen through a black medium gives red; second, that sight when strained to a distance becomes weaker and less; third, that black is in a sort the negation of sight: an object appears black because sight fails; so everything at a distance looks blacker, because sight does not reach it. The theory of these matters belongs to the account of the senses, which are the proper subjects of such an inquiry; here we need only state about them what is necessary for us. At all events, that is the reason why distant objects and objects seen in a mirror look darker and smaller and smoother, and why the reflection of clouds in water is darker than the clouds themselves. This latter is clearly the case: the reflection diminishes the sight that reaches them. It makes no difference whether the change is in the object seen or in the sight, the result being in either case the same. The following fact further is worth noticing. When there is a cloud near the sun and we look at it it does not look coloured at all but white, but when we look at the same cloud in water it shows a trace of rainbow colouring. Clearly, then, when sight is reflected it is weakened and, as it makes dark look darker, so it makes white look less white, changing it and bringing it nearer to black. When the sight is relatively strong the change is to red; the next stage is green, and a further degree of weakness gives violet. No further change is visible, but three completes the series of colours (as we find three does in most other things), and the change into the rest is imperceptible. Hence also the rainbow appears with three colours; this is true of each of the two, but in a contrary way. The outer band of the primary rainbow is red; for the largest band reflects most sight to the sun, and the outer band is largest. The middle band and the third go on the same principle.

So if the principles we laid down about the appearance of colours are true the rainbow necessarily has three colours, and these three and no others. The appearance of yellow is due to contrast; for the red is whitened by its juxtaposition with green. We can see this from the fact that the rainbow is purest when the cloud is blackest; and then the red shows more yellow. (Yellow in the rainbow comes between red and green.) So the whole of the red shows white by contrast with the blackness of the cloud around; for it is white compared to them. Again, when the rainbow is fading away and the red is dissolving, the white cloud is brought into contact with the green and becomes yellow. But the moon rainbow affords the best instance of this: it looks quite white—this is because it appears on the dark cloud and at night. So, just as fire is intensified by added fire, black beside black makes that which is in some degree white look quite white; and red is like that. Bright dyes too show the effect of contrast. In woven and embroidered stuffs the appearance of colours is profoundly affected by their juxtaposition with one another (purple, for instance, appears different on white and on black wool), and also by differences of illumination. Thus embroiderers say that they often make mistakes in their colours when they work by lamplight, and use the wrong ones. We have now shown why the rainbow has three colours and that these are its only colours.

The same cause explains the double rainbow and the faintness of the colours in the outer one and their inverted order. When sight is strained to a greater distance the appearance of the distant object is affected in a certain way; and the same thing holds good here. So the reflection from the outer rainbow is weaker because it takes place from a greater distance and less of it reaches the sun, and so the colours seen are fainter. Their order is reversed because more reflection reaches the sun from the smaller, inner band. For that reflection is nearer to our sight which is reflected from the band which is nearest to the primary rainbow. Now the smallest band in the outer rainbow is that which is nearest, and so it will be red; and the

second and the third will follow the same principle. Let B be the outer rainbow, A the inner and primary one; let C stand for the red colour, D for green, E for violet; yellow appears at the point F. Three rainbows or more are not found because even the second is fainter, so that the third reflection can have no strength whatever and cannot reach the sun.

Book 3, chapter 5 – The rainbow can never be a circle nor a segment of a circle greater than a semicircle. The consideration of the diagram will show this and the other properties of the rainbow. Let A be a hemisphere resting on the circle of the horizon, let its centre be K and let G be another point appearing on the horizon. Then, if the lines that fall in a cone from K have GK as their axis, and, K and M being joined, the lines KM are reflected from the hemisphere to G over the greater angle, the lines from K will fall on the circumference of a circle. If the reflection takes place when the luminous body is rising or setting the segment of the circle above the earth which is cut off by the horizon will be a semicircle; if the luminous body is above the horizon it will always be less than a semicircle, and it will be smallest when the luminous body reaches its meridian.

First let the luminous body be rising at the point G, and let KM be reflected to G, and let the plane determined by the triangle GKM be produced. Then the section of the sphere will be a great circle. Let it be A (for it makes no difference which of the planes passing through the line GK and determined by the triangle KMG is produced). Now the lines drawn for G and K to any other point on the semicircle A will not stand in this ratio to one another. For since both the points G and K and the line KG are given, the line MG will be given too; consequently the ratio of the line MG to the line MK will be given too. So M will touch a given circumference. Let this be NM. Then the intersection of the circumferences is given, and the same ratio cannot hold between lines in the same plane drawn from the same points to any other circumference but MN.

Draw a line DB outside of the figure and divide it so that D is to B as MG is to MK. But MG is greater than MK since the reflection of the cone is over the greater angle (for it subtends the greater angle of the triangle KMG). [Therefore D is greater than B.] Then add to B a line F such that BF is to D as D is to B. Then make another line KP having the same ratio as to B as KG has to F, and join MP.

Then P is the pole of the circle on which the lines from K fall. For the ratio of D to PM is the same as that of F to KG and of B to KP. If not, let D be in the same ratio to a line lesser or greater than PM—it will not matter—and let this line be PR. Then GK and KP and PR will have the same ratios to one another as F, B, and D. But the ratios between F, B, and D were such that FB is to D as D is to B. Therefore PG is to PR as PR is to PK. Now, if the points K, G be joined with the point R by the lines GR, KR these lines will be to one another as PG is to PR; for the sides of the triangles GPR, KPR about the angle P are homologous. Therefore, GR too will be to KR as GP is to PR. But this is also the ratio of MG to MK; for the ratio of both is the same as that of D to B. Therefore, from the points G, K there will have been drawn lines with the same ratio to one another, not only to the circumference MN but to another point as well, which is impossible. Since then D cannot bear that ratio to any line either lesser or greater than PM (the proof being in either case the same), it follows that it must stand in that ratio to MP itself. Therefore as MP is to PK so PG will be to MP [and finally MG to MK]. If, then, a circle be described with P as pole at the distance MP it will touch all the angles which the lines from H and K make by their reflection. If not, it can be shown, as before, that lines drawn to different points in the semicircle will have the same ratio to one another, which was impossible. If, then, the semicircle A be revolved about the diameter GKP, the lines reflected from the points G, K at the point M will have the same ratio, and will make the angle KMG equal, in every plane. Further, the angle which GM and MP make with GP will always be the same. So there are a number of triangles on GP and KP equal to the triangles GMP and KMP. Their perpendiculars will fall on GP at the same point and will be equal. Let O be the point on which they fall. Then O is the centre of the circle, half of which, MN, is cut off by the horizon.

For the sun does not master the parts above, but does master those near the earth and dissolve the air. And that is why the rainbow does not make a complete circle. A rainbow at night from the moon occurs rarely: for the moon is not always full and is too weak in its nature to master the air. Rainbows stand most firmly when the sun is most mastered; for then most moisture remains in them.

Again, let the horizon be AKC, and let G have risen above it; and let the axis now be GP. The proof will be the same for the rest as before, but the pole P of the circle will be below the horizon AC since the point G has risen above the horizon.

But the pole, and the centre of the circle, and the centre of that circle (namely GP) which now determines the rising of the sun are on the same line. But since KG lies above the diameter AC, the centre will be at O on the line KP below the plane of the circle AC which determined the position of the sun before. So the segment XY which is above the horizon will be less than a semicircle. For XYZ was a semicircle and it has now been cut off by the horizon AC. So part of it, YZ, will be invisible when the sun has risen above the horizon, and the segment visible will be smallest when the sun is on the meridian; for the higher G is the lower the pole and the centre of the circle will be.

In the shorter days after the autumn equinox there may be a rainbow at any time of the day, but in the longer days from the spring to the autumn equinox there cannot be a rainbow about midday. The reason for this is that the northerly segments are all greater than a semicircle, and go on increasing, while the invisible segment is small; but as to the segments south of the equator, the upper one is small and the one below the earth large—and the further away they get, the larger it becomes. Consequently, in the days near the summer solstice, the size of the segment is such that before the point A reaches the middle of the segment—its meridian—the point P is well below the horizon; the reason for this being the great size of the segment, and the consequent distance of the meridian from the earth. But in the days near the winter solstice the segments of the circles are small, and the contrary is necessarily the case: for the sun is on the meridian before the point G has risen far.

Ibn al-Haytham, *Optics*

Chapter 3 – We find that the light of every self-luminous body radiates on every body opposite to it when there is not between them an opaque or non-transparent body that screens one from the other. For when the sun faces a body on the ground that is not screened from it, its light shines upon that body and is visible, and it simultaneously irradiates every place in all parts of the earth that face it at that time. It is similarly the case with the moon, and also with fire: when [the latter] lies opposite an opaque body and there is no opaque screen between them and the intervening distance is not excessively large, the light of the fire will radiate on that body and its form will be visible. Again, the light of a fire-brand is found to radiate simultaneously on all bodies surrounding that fire on all sides, and on all opaque bodies above or below it, provided that they are not hidden from it by a screen and their distances are not too large—whether the fire-brand is small or large, so long as its light is visible on the opaque bodies that face it.

We also find that the radiation of all lights takes place only in straight lines and that no light radiates from a luminous object except in straight lines—provided that the air or transparent body between the luminous object and the body on which the light appears is continuous and of similar transparency.

When this state of affairs is examined at all times it is found to be uniform, suffering no variation or change. This becomes clearly apparent to sense if one examines the lights that enter through holes, slits and doors into dusty chambers. As for the light of the sun, when it enters through a hole into a dark chamber the air of which is cloudy with dust or smoke, the light will appear to extend rectilinearly from the hole through which the light enters to the place on the chamber's floor or walls which that light reaches. If the air in the chamber is clear and pure and the extension of the light through it is not visible, and if an experimenter wishes to examine the interval through which the light extends, then let him take an opaque body and, approaching the rectilinear interval between the hole and the place on the chamber's floor or walls where the light is, let him intercept it by the opaque body: he will find that the light will appear on that opaque body and vanish from the place where it showed on the chamber's floor or walls. If he approaches any position he chooses on the straight line between the hole and the place where the light appears, and intercepts the interval with the opaque body, the light will appear on that opaque body and vanish from the place in which it [formerly] appeared. (The straightness of this interval can be tested with a straight rod.) This state of affairs thus shows that the light that entered through the hole extends in a straight line between the hole and the place reached by the light. If the experimenter examines any interval he chooses among the crooked, bent or curved intervals between the hole and the place where the light appears, intercepting it by the [opaque] body, no light will appear [at any point] in that interval. It is so with minute holes in

opaque bodies. When sunlight irradiates such bodies, it passes through their tiny holes, extending in straight lines. If one tests the straight distance between the tiny hole and the place where the light from the hole appears, the light will be found to extend the whole length of that straight interval, even if the hole is very small. Let an experimenter take an opaque body and, having made a minute hole in it, let him hold it opposite the body of the sun: he will find that the light goes through the hole, extending on a straight line. If he tests the interval on which the light just described has extended by applying a ruler to it, he will find it to be perfectly straight. It is therefore clear from all this that the light of the sun only extends along straight lines.

Similarly, if the light of the moon is tested, it will be found to be of this description. And similarly with the light of the stars: for, in a moonless night, let any of the large stars (such as Venus, or Jupiter at its nearest position [to the earth], or also Mars at its nearest position, or Sirius) be opposite a hole giving into a dark chamber: its light will appear in the chamber and will be found opposite the hole. If the observer places his eye in that light and looks towards the hole, he will then see the star facing him. If he observes the star for some time until it has moved through an appreciable distance, its light in the chamber will be found to have moved from its [former] place so as to be rectilinearly opposite the star. And as the star moves, that light will move, and the light and the hole and the star will always be found to lie on a straight line.

Then if, with the aid of an opaque body, the experimenter tests the light from the star that appears at the place opposite the hole in the manner we have shown before, by intercepting the straight distance between the place in which the light appears and the hole through which the light enters at any point he chooses on that distance, the light will appear on the opaque body and will vanish from the place in which it [previously] appeared.

Similarly, if there is a fire facing a hole that leads into a dark chamber, the light of that fire will appear in the chamber opposite the hole. And if one tests the straight interval between the light and the hole in the way we have mentioned, the light of the fire will be found to pass through every point on it. The light of the fire may also be tested with a straight rod, provided that the interval between the fire and the hole is short and the interval between the hole and the place where the light appears is also short. For if a straight rod is inserted in the hole through which the light has entered and one end is placed at the point of visible light, its other end will be found at the fire or in a straight line with it, so that the fire, the hole and the light that appears in the chamber after it has entered through the hole will always be found on a straight line.

This property also becomes manifest from the shadows of all kinds of light. For when erect opaque objects are irradiated with light (and) their shadows appear on the ground or on the opaque bodies opposite them, these shadows are always found to extend rectilinearly, and the shadowed regions are found to be those whose straight distances from the luminous body (the light of which has been cut off from those places) have been intercepted by the objects casting the shadows.

It thus appears from all that we have said that the lights from self- luminous bodies can radiate only in straight lines.

We also find that light radiates from every part of every self-luminous body. And we find that the light that radiates from the whole luminous body is stronger than that which radiates from a part of it. And we find that the light that radiates from a larger part is stronger and more manifest than that which radiates from a smaller part. With regard to the sun. when it begins to rise above the horizon, only a small part of its circumference appears at first, and yet the light of that part radiates upon all facing walls and objects and parts of the earth's surface, while at this moment the centre of the sun is hidden below the horizon and concealed from anything on the earth's surface. Then, as the visible part becomes larger, the light grows and becomes stronger, until the centre of the sun comes up. The light continues to grow until the whole body of the sun becomes visible. And similarly when the sun sets: for as long as a part of it is visible above the horizon, the light of that part will radiate upon the surface of the earth, even though the centre of the sun and the larger part of its body are hidden from those places which are irradiated by the light of that visible part of the sun.

Now this fact, I mean that the light radiates from the circumference of the sun's body, holds for all horizons. But that part of the sun which is the first to appear at one horizon is not the same as the part which is the first to appear at another horizon — this being due to the motion proper to the sun. Thus the parts of the sun that appear at the beginning of its rising at different horizons are different, especially on different days. And the same holds for the parts of the sun that are the last to set. And, in general, for each place on the

earth from which a part of the sun is visible (whether it is a part of the sun's circumference or not), the light will radiate from that part on that place. It is thus manifest from this consideration that [light] radiates from every part of the body of the sun upon every body facing that part, even though the centre of the sun and the remainder of its bulk may be hidden from that body.

Further, when the sun is partially and not completely eclipsed and a part of it remains visible, light radiates from that visible part upon every place on the earth facing it at the time of the eclipse. When the sun is observed at the time of an eclipse that covers most of it and includes its centre, the eclipsed part will be found to grow larger while the remaining part becomes smaller. And yet, from whatever part of the sun that remains, the light will radiate upon the surface of the earth, and that part will be visible in every opposite place and also in every place opposite any portion of that part. And if the light of the sun is examined at the time of eclipse, it will invariably be found to radiate in straight lines, just as it did before the eclipse; further, the light of the sun that appears on the earth at the time of the eclipse will be found to be weaker than its light before the eclipse. And as the eclipsed part becomes larger and the remaining part smaller, the light visible on the earth becomes weaker. But the remaining part of the sun at the time of an eclipse covering most of the sun is but a part of the sun's circumference. And the condition of the whole circumference of the sun is one and the same. Therefore this consideration makes it manifest that the light of the sun issues from the whole body of the sun and from every place on the sun and not only from a particular place on it.

It is also manifest from this consideration that the straight lines along which the light of the sun extends do not all proceed from the centre of the sun. Rather, the light issues from every part of the body of the sun on every straight line that can be imagined to extend from that part. For when the eclipse covers most of the sun with respect to a particular place on the earth, the centre of the sun is at that time hidden from that place. The straight lines between the centre of the sun and that place are thus interrupted. But the light still radiates upon that place from the rest of the sun. Thus if the light did not proceed on lines other than the straight lines extending from the sun's centre, it would not be visible at the time of eclipse in those places of the earth from which the centre is hidden. Further, [consider] those places on the earth with respect to which the sun has descended from the zenith at the time of eclipse in the direction of the exposed, visible part. At this time the light radiates on those places from the exposed part of the sun [in a direction inclined] towards the side on which the centre of the sun is, and in straight lines that cannot pass through that centre. And the light radiates at this time on every place from which a part of the body of the sun can be seen and with respect to which the eclipse does not cover the whole body of the sun. Therefore, the light of the sun does not only radiate in straight lines extending from the centre of the sun, but in all the lines that may rectilinearly extend from every part of it.

Further, when the sunlight passes through apertures it is always found to diverge, and as the light recedes from the aperture it becomes wider. This is evident in the case of minute apertures. When sunlight has passed through a minute aperture and appears on a place far removed from the aperture, such light is found to diverge — the area on which the light appears being many times wider than the aperture. As the distance between the aperture and the area where the light appears increases, the light becomes wider. And if the straight interval between the aperture and the visible light is interrupted by an opaque body, the light will be found on that opaque body. But the light on that body will be narrower than that which was visible at the former place. And as this body approaches the aperture, the [patch of] light appearing on it will become narrower. And as it is moved farther from the aperture the patch of light appearing on it will grow wider. Thus it is evident from the widening of the light issuing from minute apertures that the light of the sun extends from every part of it, and not just from a particular part.

From this it is also evident that light extends only along straight lines. For if the light extended [only] from the centre of the sun or from a particular point on it, then the light extending from that point on the lines drawn from it to the narrow aperture would insensibly diverge after passing through the aperture. For the divergence would be determined by the diameter of the aperture, the distance of the sun from the aperture and from the place where the light appears. But as far as sense is concerned there is no appreciable difference between these two distances by comparison with the distance of the sun. Thus the light issuing from the minute aperture and appearing on the ground (or on some other place) would be equal in magnitude to the aperture, especially if the aperture is cylindrical. It would also come about that if sunlight passed through a narrow cylindrical hole, and the position [of the hole] were slightly altered so that the straight line extending through its length to the body of the sun would not meet that point on the sun, no

light would come out of or go through the hole. Further, if light extended on other than straight lines, then, having come out of a minute aperture, it would extend on non-rectilinear lines. Therefore, the expansion of the light passing through minute apertures is clear proof that the light issues from the whole body of the sun to the aperture, and that it issues in straight lines. That is why when it comes out of the aperture it diverges and widens, this divergence taking place in straight lines. For light diverges as it proceeds from the whole body of the sun to the narrow aperture, and as it comes out of the aperture and goes forward, another cone opposite the first one is produced, since light proceeds in straight lines. It thus appears from all that we have explained that the light of the sun radiates from every part of the body of the sun to every side directly opposite that part.

The case of the moon is more manifest. For the light of the crescent moon is visible on the earth's surface on the second night of the month and on following nights. And, especially when the moon faces a dark place, its light appears in that place though it is still incomplete and faint. Its light then grows every night with the increase of its magnitude until it is full. When this happens its light is found to be stronger than on previous nights. Again, the case of the full moon at rising and setting is similar to that of the sun, and the same is true of the moon at eclipses when these extend beyond its centre but do not cover the whole moon. Also, if the moonlight that has passed through tiny holes is tested when the moon is full, it is found to expand, and as it recedes from the hole it grows wider. It therefore appears from this expansion that moonlight radiates from every part of the moon and not from a particular part of it, and that the extension of the light of the moon can take place only in straight lines.

This same property also holds for fire. For when a fire is divided into parts by dividing the subject sustaining it, some light will radiate from each of these parts, and the light of each part will be found weaker than that of the whole fire, and the light of a smaller part will be found weaker than that of a larger part. The parts of the fire may also be tested without being divided. To make such a test take a fairly wide copper sheet and make a fairly large circular hole in it; slide through this hole a well-straightened cylindrical tube of regular circularity and convenient length; let the width of the hole and that of the tube be of the same magnitude and let the tube's aperture not exceed the thickness of a needle; insert the tube into the hole in the sheet so that its end may be level with the sheet's surface; attach this sheet to some object at a point above the ground, and let it stand vertically on its edge. Now, in the darkness of night, bring a flame to the vicinity of this sheet and let it be that of a lamp with a broad, bright wick. Hold the flame opposite the hole, then move it closer to the hole until it is so near that no measurable distance exists between them. The area on the side of the tube will then be shaded by the sheet. Let no light be present save the flame being tested, and let this [experiment be carried out] in a place unswept by winds. Hold an opaque body opposite the end of the tube. The light of the flame will appear on that body. But no light is available except that which has passed through the tube; and no light has passed through the tube except the light of that part of the flame opposite the tube's aperture; its area is equal to that of the tube's aperture. For light proceeds only in straight lines, and no uninterrupted straight lines exist between the light appearing on the body at the end of the tube and any part of the flame other than that opposite the [other] end of the tube. For the straight lines between [this part] and the visible light extend inside the tube without the interruption of any opaque body. As for the remaining parts of the body of the flame, light will proceed from them only to the adjacent end of the tube's aperture; so that if any of this light enters the end of the tube it will be interrupted by the tube's wall and abolished and will not pass through the length of the tube. In this case, then, only the light of the part opposite the tube's end will pass through the length of the tube's aperture.

The experimenter should then gently move the flame so that another part of it may face the hole, and then inspect the body opposite the end of the tube on which the light was visible. He will find that the light is still visible on that body. If he then moves the body of the flame in all directions, raising and lowering it so that the hole may face one part of the flame after another, he will find that the light appears in all cases on the body opposite the tube. He will also find this light to be weaker than the light of the whole flame when it shows on bodies exposed to the whole bulk of the flame at a distance equal to that between the flame and the place where the light that has passed through that body appears. Let the experimenter narrow the hole by sliding a thin straight body into the tube, thus partly obstructing it, and let him fix this body to the tube's interior surface. If he tests the light coming through the rest of the tube, he will find it still visible on the body opposite the tube, unless the remaining part of the tube is too narrow. He will also find that the light that appears when the tube is made narrower is smaller and also less visible and weaker than the former light. Therefore, it appears from this experiment that light radiates from each part of the fire; that the light

from a whole fire-brand is stronger than that from a part of it; and that the light from a greater part is stronger than that from a smaller part.

Again, let the experimenter fix the flame close to the hole in the sheet so that it will not move and so that the same part of it will remain opposite the hole; let him then incline the tube so that it will be in an oblique position to the surface of the sheet while its end remains attached to the hole; he should plug any gap (if such appears) at the end of the tube or at the hole in the sheet at its rear; and let him hold the opaque body opposite the tube. He will find that light appears on the opaque body. If he alters the position of the tube by inclining it to another side, and in front of it holds the opaque body on which the light may appear, he will find that the light is still visible on it. By inclining the tube in all directions he will find that the light proceeds from that part of the flame to all sides directly opposed to it. If he then moves the flame so that another part of it will be opposite the hole, and tests that part too at those inclined positions in which the first part was tested, he will find that the light also proceeds from this part to all opposite sides. If he similarly tests every part of the flame he will find it to be of this description. It appears from this experiment that the light radiates from each part of the flame to every side directly opposed to that part.

Robert Grosseteste, *On Colour*

Colour is light embodied in a diaphanous medium. Indeed, this medium possesses two different qualities, for it is either pure, without the element of earth, or impure, mixed with the element of earth. Now, light is divided four ways, namely, it is either bright or dim, scarce or copious. I do not say that copious light is light diffused through a large expanse; rather, I say that copious light is gathered as if in a point when a concave mirror is positioned facing the sun and light falling over the whole surface of the mirror is reflected towards the centre of the sphere of the mirror. Thus, by the collection of this light in the very centre combustible material is very quickly set on fire. So, bright and copious light in a pure diaphanous medium is whiteness; scarce and dim light in an impure diaphanous medium is blackness. This statement explains the statement of Aristotle and Averroes who posit that blackness is privation and whiteness is property or form.

It also follows from this statement that there are seven colours close to whiteness (no more, no fewer), in which can occur recession and permutation from whiteness towards blackness. Similarly, there will be seven colours close to blackness, through which ascent occurs from blackness towards whiteness, until there is a meeting with the other seven colours through which descent from whiteness occurs. For since three elements constitute the essence of whiteness, that is, the abundance of light, its clarity and the purity of the diaphanous medium, when two of these elements remain, diminution of any third element can occur, and in this way there will be the generation of three colours; or, when only one of these three elements remains, diminution of the remaining two will occur, and so there will be the generation of three colours different from the former three; or there will be diminution of all three elements at once, and thus in total there will be an immediate progression of seven colours from whiteness. The ascent from blackness towards whiteness by seven colours which are close to black is demonstrated by the same reasoning.

Therefore there will be in total sixteen colours: that is, two extremes and seven connected to each extreme, ascending from one through intensification and descending from the other through diminution towards a middle space, where they run into each other. However, in any of the colours in the middle the degrees of intensification and diminution are infinite. Therefore, the colours that were fourteen through the counting and combining of the elements that are intensified or diminished (namely, abundance, clarity and the purity of the diaphanous medium, and their opposites), will become infinite through counting the degrees of intensification or diminution.

What is understood in this way about the essence of colours and their multiplication, becomes apparent not only by reason but also by experience to those who thoroughly understand the depth of the principles of natural science and optics. And this is because they know how to make the diaphanous medium either pure or impure, so that in it they can receive bright light, or dim if they prefer, and through the shape formed in the diaphanous medium itself they can make scarce light, or increase that same light at will; and so through skilful manipulation they can show visibly, as they wish, all kinds of colours.

Robert Grosseteste, *On the Rainbow*

Optics and physics have to speculate on the rainbow. However, the same "what" the physics needs to know, is a "because of what" the optics needs. And in fact, Aristotle, in the book on the meteorology, did not show "because of what", in the sense of optics, but "what" is the rainbow, which is physics, in a quite short discussion. Hence, here, in this paper, the "because of what" concerning optics is started discussing and explaining in our manner and time opportunity.

First then, let us say that optics is a science based on the figures of the visual perceptions, and it is subaltern to the science based upon figures and schemes, which contains lines and radiating surfaces, being them cast by the radiating sun, or by stars, or by any other radiant body. And it has not to be thought that the going out of visual rays from eyes is only a virtual argument, without any reality, as people, who consider "the part and not the whole", are arguing. But let us note that visible objects are of a nature similar to the nature of the shining and sparkling sun, the radiation of which, combined with the radiation of the external surface of a body, completes the total perspective of vision.

Therefore, some philosophers, handling these natural things, are considering the natural visual perception as passive, that is, as an "intro-mission". However, mathematicians and physicists, concerning the nature of visual perception, consider that it occurs according to an "out-emission". Now, this part of the sight, which is effected by an out-emission, Aristotle plainly discussed in the last chapter of his book on the animals, that "the back of the eye sees far away; from its emission it is not divided, nor consumed, but its ability of sight goes forward from him and right to the things we are seeing." And again, in the same: "Three are our conscious senses, namely, sight, hearing and smell; they come out from the organs, just as water emerges from canals, and therefore a long nose has a good smelling." In optics, then, the true position concerning the rays is that of their emission. Of which (optics), there are three main parts, according to the three ways of transition the rays have to the objects of vision. Either the path of the rays to the visible object is straight through a transparent medium having a specific feature, interposed between who is looking and the object. Or, it is ruled by a path directed to a body having a virtual nature, that is, a mirror, reflected by it, back to the object we are seeing. Or it is the passage of the rays through more transparent media of different kinds, where, at the interfaces, the ray is broken and makes an angle, and the ray comes to the object not with a straight path, but by means of several straight lines, having a number of angles at the related interfaces.

The first part of this science is named "de visu", the second "about mirrors". The third part is coming in our possession unknown and untouched. We know, however, that Aristotle had discussed this third part, which is the much more difficult, and the subtlety of which was by far the more remarkable, emerging from the deep heart of Nature. This part of optics, if fully understood, shows us the way in which we can made objects at very long distance appear at very close distance, and large things, closely situated, appear very small, and small things at a certain distance we can see as large as we want, so that, it is possible for us to read the smallest letters at incredible distance, or count the sand, or grain, or grass, or anything else so minute. In what way, however, it is necessary to understand how this wonder happens, so it will become clear to everybody.

Visual rays, penetrating through several transparent different materials, are broken at interfaces; and the parts of these rays, in the different existing transparent materials, at the interface of those are angularly connected. This, however, is clear by means of an experience, the principle of it is set down in the book on the mirrors: if we cast an object into a vessel, and the distance is assumed that it may not be seen, and some water poured into, it will be seen what is inside. And the same is displayed by a body having a continuous nature too; therefore, the visual ray, at the interface of two transparent media with different features, is subjected to a contiguity law. When one total ray is generated from a source, the continuity of it cannot be broken, except when its generation is broken, and at the interface of two transparent media, the ray cannot be discontinuous; at the interface, we cannot have a full continuity and a complete discontinuity and therefore, at each point of the interface the two parts of the ray are, not directly, but angularly connected.

But, how large is the angular deviation from the straight path associated to a ray? Let us consider the ray from the eye through the air medium, incident on a second transparent medium, as a straight line to the point, where it is incident on the transparent medium; then let us make the line deep in the transparent medium, line that makes equal angles with the surface of transparent medium, that is, normal to the interface. I say, therefore, that the prolongation of the ray in the second transparent medium is following a line, separating of a certain angle, which is one half of the angle "i" obtained as follow. "i" is the angle given

by the line which is the prolongation of the ray, without interruption and direct, drawn away from the point of incidence deep into the medium, equal to the angle “i”, drawn above the surface of the second transparent medium. So we have determined the amount of the refractive angle of the rays. We know that there are similar experiments giving the refraction of the rays on mirrors, fitting an angle equal to the angle of incidence. And the same tells us that principle of the philosophy of Nature, namely, that "every action of the Nature is well established, most ordinate, and in the best and shortest manner as it is possible."

Moreover, the object which is seen through a medium composed of several transparent materials, does not appear to be as truly is, but it is appearing composed by the concurrence of the rays from the eye, continuous and direct, and by the lines starting from the viewed object and falling on the following surface, the nearest to the eye, according to its normal. This is clear to us from experiments and similar reasoning that we know: that an object seen in a mirror appears in the concurrence of the propagation of the lines of sight and the lines drawn directly upon the surface of the mirror, normal to this surface.

It is evident then what is the quantity of the angle according to which the ray is broken at the interface between transparent media and where the image of an object appears arising from several transparent media. Let us add also those principles of optics, which are given by the philosophers studying the natural phenomena, then we have the following: given the amount of the angle under which an object is seen, it appears its position and size, according to the order and organization of the rays. It is not the great distance rendering a thing invisible, except by accident, but the smallness of the angle under which it is seen. It is clear that it is possible, using geometrical ratios, knowing the position and the distance of the transparent medium, and knowing the distance from the eye, to tell how an object appears; that is, given its distance and size, it is possible to know the position and the size of the image. It is also clear how we can design the shape of the transparent medium, in order to have this medium able to receive the rays coming out from the eye, according to the angle we choose, collecting and focusing the rays as we like over the observed objects, whether they are large or small, or everywhere they are, at long or short distances. In such a way, all objects are visible, in the position and of the size given by the device; and large objects can appear short as we want, and those very short and at a far distance, on the other hand, appear quite large and very perceptible.

And in the third part of optics we have the study of the rainbow. Undoubtedly, it is not possible the rainbow be given by a direct crossing of the solar rays in the cavities of the clouds. Because the continuous illumination of the cloud does not produce an arc-like image, but some openings towards the sun, through which the rays enter the cavity of the cloud. And it is not possible that the rainbow is produced by a reflection of the rays of the sun upon the surfaces of the raindrops falling down from the cloud, as reflected by a convex mirror, so that the cavity of the cloud receives in this manner the reflected rays, because, if it would be so, the rainbow would not be an arc-like object; moreover, it would happen that increasing the altitude of the sun, the rainbow would be greater and higher, and decreasing the sun altitude, the rainbow would be smaller; this is contrary to what is shown by the experience. It is therefore necessary that the rainbow is created by the refraction of the sun's rays by the humidity carried by the cloud. Let me tell then, that outside the cloud is convex and inside it is hollow. This is clear from the nature of “light matter” and “heavy matter”. And that, what we see of a cloud is smaller than a hemisphere, even though it appears to us as a hemisphere, and when the humidity comes down from inside of the cloud, it is necessary that it assumes the volume of a convex pyramid at the top, descending to the ground, and therefore it is condensed in the proximity of the earth, more than in its upper part.

Then, there are four transparent media overall, through which the rays of the sun penetrate, that is, pure air containing the cloud, second the cloud itself, third the highest and most rarefied humidity coming from the cloud, and fourth, the lower and denser part of that humidity. From all the things discussed before on refraction and related angles at the interface between two media, it is necessary the rays of the sun are first refracted at the boundary of air and cloud, and then at the boundary of cloud and humidity, so that, after these refractions, the rays are conveyed in the bulk of humidity, and after, they are broken again though its pyramidal cone, however, not assuming the shape of a round pyramid, but in the form similar to the curved surface of a round pyramid, expanded opposite to the sun. Therefore its shape is that of a bow, and to us (in England), the rainbow can be austral, and, because the aforesaid cone is close to the earth, and it is expanding opposite the sun, it is necessary that more than a half of that cone falls below the surface of the earth, and the rest of it falls on the cloud, opposite the sun.

Accordingly, on sunrise or sunset, a semicircular rainbow appears and is larger; when the sun is in other positions, the rainbow appears as a portion of the semicircle. And, when the altitude of the sun is increasing, the portion of the rainbow decreases. And for this reason, in those places where the sun can reach the zenith, the rainbow never appears at noon. Aristotle tells that the "quantity" of the different arcs we can see on sunrise and sunset is small, but, Aristotle's small "quantity" is to be understood not concerning the "size" but the luminosity, which happens because the rays are passing, during these hours, through a large quantity of vapor, much larger than in other hours of the day. Aristotle himself suggests as a consequence, that there is a reduction of that which shines because of the rays of the sun in the clouds.

For what concerns the colours of rainbows, let us remember that color is light mixed with a transparent medium; the medium is diversified according to the purity and impurity, and the light is fourfold divided; it is to be divided according to the brightness, and of course, to the obscurity, and according to intensity and tenuity; and according to these six different enumerations the variety of all the colors is generated, the variety of colors that appears in the different parts of a single rainbow, is mainly due to the intensity or tenuity of the rays of sun. Where there is a greater intensity of light, it appears that the colors are more luminous and brighter: but where there is less intensity of light, it appears that the color turns to the dark color of Hyacinthus. And because the intensity of light and the decrease of intensity is not subjected to a rule, except in the case of light shining on a mirror, or passing through a transparent medium, which, by means of its own shape, can gathers the light in a certain place, and, in a certain place can disrupt the light, diminishing it, and the arrangement of receiving the light is not a fixed one, it is clear that that it is not in the skill of an artist to reproduce the rainbow, but it is possible to imitate accordingly to a certain arrangement.

On the other hand, the difference of the colors of a rainbow from those of other rainbows is due to the purity and impurity of the transparent medium supporting it, as well as from the brightness and obscurity of the light impressing it. If we have a pure transparent medium and bright light, the color is whitish. If the recipient medium is a mixture of vapors and mist and the light is hazy, as occurs near the East and West, the colors are less splendid and their brightness reduced. In the same manner, according to the enumeration of brightness and obscurity of light and of purity and impurity of the medium, all the arcs of various colors can be seen. Here is the end of the discussion on the rainbow, according to the Lincolnian.

John Peckham, *Perspectiva communis*

The investigation of mirrors is threefold: first, understanding the nature of and differences between mirrors and the manner and place of reflection; second, locating images; third, investigating the differences between [various] errors of reflection and the differences between mirrors.

The first part of this threefold investigation is consigned to the fourth, the second part to the fifth, and the third part to the sixth [book of Alhazen].

Primary and pure secondary light and unmixed colors rebound from the surfaces of dense bodies.

This is evident from experience with mirrors of iron and other materials. Moreover, because rays are reflected from the surface of the earth, heat is more intense near the earth than in the middle interstice of the air and [intense] in valleys to which rays are reflected by the density of the mountains on both sides. The reason for this is that rays of light and color are so constituted as to proceed through a transparent body, and the power of radiating and the onward flow of rays are not brought to an end by the opposition of a dense body of negligible transparency; since the rays cannot continue in a straight line—when opposed not only by opaque and terrestrial bodies, but also by transparent bodies having a weaker kind of transparency, such as water and glass—the impulse to diffuse produces reflection. Therefore as to its nobler purity a solar ray is reflected from water; nevertheless, some part of it enters and illuminates water. Therefore a person situated in water would be able to see the sun and moon.

Only reflection from a regular surface is discerned by the eye.

I call those surfaces regular that are of uniform disposition in all their parts, as plane, concave, convex, and so forth. The surfaces of rough bodies are irregular, and light incident on them is dispersed and scattered so that it cannot fall on the eye in a regular fashion. However, light is reflected from regular surfaces in the form of radiant pyramids in the same order in which it is received. Therefore, since sight occurs only through radiant pyramids, observation [by reflection] occurs only through such [regular] surfaces and not

through others for just as the rays, if extended in straight lines, would exhibit to the eye the object to which they belong, so they exhibit it when they have been reflected, although in a different way, for it is essential to rays to manifest the bodies of which they are the likenesses.

Reflected light or color is weaker than that which is radiated directly.

This is caused not only by the separation [of the light or color] from its source, but also (and more significantly) by the weakness due to bending. Since straightness is naturally associated with the propagation of light (as well as with every other action of nature), it arranges and orders nature, for every action is strong in proportion to its straightness; consequently when straightness is lacking, strength is decreased. This is why light from the sun passing through colored glass causes the color [of the glass] to radiate sensibly and to bathe facing opaque bodies in color, i.e. because rays are strong when they radiate in a straight line or nearly so. However, a ray reflected from a dense body cannot cause the glass to radiate sensibly, since the light must be strong enough not only to move the color itself, but also to move the medium along with it the strength of the [solar] ray penetrating the glass exceeds this [requirement] even though it is slightly refracted.

Reflections from strongly colored surfaces affect vision slightly or not at all.

As shown in the preceding proposition, the reason for this is that direct light and color are stronger than reflected light and color. However, if the [reflecting] surface is regular and highly polished, objects will be visible in it, not as they really are but vested with the color of the mirror.

Light and color reflected from mirrors manifest to the eye the objects of which they are the species.

This is evident, because a species produced by a visible object has the essential property of manifesting the object of which it is the likeness for since the species has no permanent being in itself, it necessarily reveals the object of which it is species. Therefore even though it is reflected, it maintains its essence and thereby reveals the object— albeit in another position, the reason for which will be evident below.

The angles of incidence and reflection are equal, and the incident and reflected rays are in the same plane as the line erected perpendicularly at the point of reflection.

The angle of incidence is that angle formed by the incident ray and either the surface of the mirror (on one side) or the imaginary line erected perpendicularly at the point of reflection (on the other side) the angle formed by these [lines] and the reflected ray is called the angle of reflection. Equality of the angles is gathered from experience and proved by reason in any of several ways; for if an incident ray could advance into the depth of a mirror, it would form (with the perpendicular extended into the depth [of the mirror] at the point of reflection) an angle equal to the angle of incidence because, as Euclid demonstrates, vertically opposite angles are equal. Therefore the ray recoils according to the same mode as that by which it would be transmitted [if the object were transparent], and consequently it must rebound at an angle equal [to the angle of incidence]. Accordingly, if it is incident on the mirror perpendicularly, it is reflected back on itself; if it is incident obliquely, it is reflected obliquely toward the other side. The same thing is evident in the motion of a body, since a heavy body descending rectilinearly onto a solid body or projected perpendicularly along a line is driven back along the same line; if projected obliquely, it rebounds along a similar line on the other side.

Furthermore, the perpendicular ray is stronger than [all] others, not only because of the absolute nature of the ray, but also because of the mode of incidence on the object, as the exposition of proposition fifteen part one makes clear. Therefore the strength of the incident ray varies with the size of the angle of incidence, and the strength of the reflected ray varies with the strength of the incident ray; consequently the mode of reflection follows the mode of incidence. It is evident also that the three lines [i.e. the incident ray, reflected ray, and perpendicular] are in the same plane, because a ray conforms as closely as possible to a rectilinear path, since straightness is natural to light. However, if the ray were to forsake that plane, it would have departed doubly from straightness, both by rebound and by deviation.

Transparency is not essential to mirrors, but may be conferred on them as an accident.

For if (as is now evident) an object is exhibited in a mirror by reflected rays, transparency, through which a species proceeds into the depth of the mirror, obstructs rather than aids sight, since reflection occurs at a dense body because of its density. Therefore common glass mirrors are coated with lead. But if, as some say, transparency were essential to mirrors, the latter could not be made of iron and steel —so far removed from transparency—nor of polished marble; but the contrary is true, let observation [of objects by

reflection] is not efficacious in iron and such materials because of the intensity of their blackness. Nevertheless, observation [by reflection] is clearer in certain stones of weak color than in glass,

Nothing is seen in glass mirrors from which the lead has been scraped.

The reason for this is that although some reflection can occur from a glass surface, direct light passes through when the glass is not shaded, on the other side, and its strength overcomes, the reflected light, as proposition three of this part makes clear. But if a black and darkened cloth or something of that kind is applied [to the mirror], the reflected light can be seen because nothing is transmitted directly through the glass, which is then of great efficacy in radiating.

Regular reflecting surfaces are sevenfold.

Indeed mirrors are plane, spherically concave or convex, pyramidal and polished either inside or outside, or columnar and polished either inside or outside. As will be evident, individual things vary in appearance according to the following seven different types [of mirrors]: plane, spherically concave and convex, pyramidal inside and outside, and columnar inside and outside. However, some surfaces are irregular, i.e. partly plane and partly convex or concave; even though such surfaces are polished, figures appear distorted in them because of irregular reflection resulting from variations in the surface.

The matter of mirrors is intense smoothness, the form perfect polishing.

By 'smoothness' is meant great continuity of parts altogether free from sensible pores; therefore wood and such bodies cannot be mirrors. By 'polishing' we understand the removal of all roughness. Consequently if a body is very smooth and highly polished, it is essentially a mirror. However, so that the mirror may represent visible things clearly, it must not be sensibly colored. It is required also that it should not be covered with dust, breath, or moisture, and for this reason they say that a mirror must be wiped clean.

Objects always appear dimmer in mirrors than by direct vision.

As proposition three shows, the explanation of this is that reflected forms are weaker and therefore represent [the object] more weakly. Consequently they act [on sight] weakly, for which reason a man remembers his own appearance with difficulty. Furthermore, the color of the mirror is mingled with the reflected light and obscures it, and consequently the face appears tinted. Moreover, blemishes of the face remain hidden because of the weakness of reflection.

3. Light, Vision, and Colour in Cosmology and Theology

Texts:

1. Bible, Genesis, 1:1-8. KJV
2. Bible, Gospel of John, 1:1-14. KJV
3. al-Qur'ān, Sura an-Nur (excerpts). Transl. Sahih International
4. Augustine, On Free Will, book 2 (excerpts). Transl. P. King (Cambridge, 2010), 51-64.
5. Al-Kindi, *On Rays*, chapters 1-3. Transl. P. Adamson and P.E Pormann (Oxford, 2012), 219-28.
6. Hildegard of Bingen, *Letter to to Guibert of Gembloux* (excerpts). Transl. B. Newman ("Hildegard of Bingen: Visions and Validation," 1985), 164-5.
7. Grosseteste, *On Light* (excerpts). Transl. N. Lewis (Toronto, 2013), 239-244.

Bible, *Genesis*

In the beginning God created the heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters. And God said, Let there be light: and there was light. And God saw the light, that it was good: and God divided the light from the darkness. And God called the light Day, and the darkness he called Night. And the evening and the morning were the first day. And God said, Let there be a firmament in the midst of the waters, and let it divide the waters from the waters. And God made the firmament, and divided the waters which were under the firmament from the waters which were above the firmament: and it was so. And God called the firmament Heaven. And the evening and the morning were the second day.

Bible*, Gospel of John*

In the beginning was the Word, and the Word was with God, and the Word was God. The same was in the beginning with God. All things were made by him; and without him was not any thing made that was made. In him was life; and the life was the light of men. And the light shineth in darkness; and the darkness comprehended it not. There was a man sent from God, whose name was John. The same came for a witness, to bear witness of the Light, that all men through him might believe. He was not that Light, but was sent to bear witness of that Light. That was the true Light, which lighteth every man that cometh into the world. He was in the world, and the world was made by him, and the world knew him not. He came unto his own, and his own received him not. But as many as received him, to them gave he power to become the sons of God, even to them that believe on his name: Which were born, not of blood, nor of the will of the flesh, nor of the will of man, but of God. And the Word was made flesh, and dwelt among us, (and we beheld his glory, the glory as of the only begotten of the Father,) full of grace and truth.

al-Qur'ān, Sura an-Nur

Allah is the Light of the heavens and the earth.

The example of His light is like a niche with in which is a lamp,

The lamp is within glass, the glass as if it were a pearly [white] star,

Lit from [the oil of] a blessed olive tree,

Neither of the east nor of the west,

Whose oil would almost glow even if untouched by fire.

Light upon light.

Allah guides to His light whom He wills.

And Allah presents examples for the people,

and Allah is Knowing of all things.

Augustine, *On Free Will.*

Book 2, 9.27 – Augustine: I only wish that nobody were in doubt about the highest good, the way nobody doubts that, whatever the highest good is, human beings can become happy only when it is possessed. But since this is an important question and might call for lengthy discussion, let us suppose that there are exactly as many different highest goods as there are different things that are sought by various people as the highest good. Surely it does not follow that wisdom itself is not one and common to all, just because the goods that they discern and elect in it are many and diverse?

If you think this, you can also doubt that the Sun's light is one, since there are many different things we discern in it. Each person voluntarily elects which of these many things to enjoy through the sense of sight: One gladly looks at a mountain peak and takes pleasure in the sight; another at the level plain; another at the hollow of the valley; another at the green forest; another at the shifting surface of the sea; another brings all these or some of them together for the pleasure of looking at them. Consequently, there are many different things that people see in the Sun's light and elect [to look at] for their enjoyment, despite the fact that the light itself is one – the light in which the person's gaze sees and grasps the sight of any one of them. Likewise, there are many different goods from which a person elects what he wants and, by seeing and grasping it for his enjoyment, sets up the highest good for himself rightly and truly. Yet it can still happen that the light of wisdom itself, in which these things can be seen and retained, is one and common to all wise people.

Book 2, 11.32-33 – Enough of wisdom's being found inferior in comparison with number! They are the same, but this calls for an eye able to discern it. Now one senses the brightness and the heat in a fire as "consubstantial," so to speak, nor can they be separated from one another. Yet the heat affects only what is moved close to it, whereas the brightness is diffused far and wide. Likewise, the power of understanding that is present in wisdom warms those close to it, such as rational souls, whereas things that are farther away, such as physical objects, are not affected by the heat of wisdom but are [merely] suffused with the light of numbers.

Well, perhaps this is still obscure to you, since no analogy drawn from what is visible can apply in every respect to something invisible. Merely pay attention to this point, which is enough for the investigation we have undertaken and is obvious even to humbler minds like ours: Even if we cannot be clear whether number is in wisdom or derives from wisdom, or whether wisdom itself derives from number or is in number, or whether each can be shown to be the name of a single thing, it is certainly evident that each is true, and unchangeably true.

Consequently, you will not deny that there is unchangeable truth, containing everything that is unchangeably true. You cannot call it yours or mine or anyone else's. Instead, it is present and offers itself in common to all who discern unchangeable truths, like a light that is miraculously both public and hidden. Who would claim that everything present in common to all who reason and understand pertains to the nature of any one of them in particular? You recall, I think, our discussion of the bodily senses a little while ago.41 We said that those things that we touch in common with the senses belonging to the eyes or to the ears, such as colors and sounds (which you and I see simultaneously or hear simultaneously), do not pertain to the nature of our eyes or ears but rather are common objects for us to sense. The same applies to those objects you and I recognize in common, each with his own mind. You would never say that they pertain to the nature of my mind, or to the nature of your mind. You cannot say that what two people see with their eyes simultaneously belongs to one set of eyes or the other, but rather some third thing at which the gaze of each is directed.

Book 2, 16.43 – Woe to those who turn themselves from your light and hold fast with delight to their own darkness! Turning their backs on you (so to speak), they are chained to fleshly labor as to their own shadows. Yet even then, what gives them pleasure shares in the encompassing brilliance of your light. But when a shadow is loved, it makes the mind's eye weaker and less fit to reach the sight of you. Consequently, a man is plunged farther into darkness when he eagerly pursues anything that catches him the more readily in his weakened condition. Due to this, he begins to be unable to see what exists in the highest degree. He starts to think evil anything that deceives him through his lack of foresight, or that entices him in his need, or

that torments him in his captivity – although he deservedly suffers these things because he has turned away, since whatever is just cannot be evil.

Al-Kindi, *On Rays*

Chapter One – All men who perceive objects of sensation grasp them in a certain form. Because they grasp them in this way, they realise through the exercise of reason that these individuals perceived by sensation correspond to certain forms, and conversely, differ from others. When they use sensation in this way, the function of reason agrees with it, as it grasps the things in a shared form [i.e., things which have the same form] individually by excluding what does not share [this form], owing to the ruling unity of each man. This act of mental understanding by the intellect is called 'universal' after the things that are grasped in this way [i.e. by the intellect universally]. According to the nature of the form which is grasped, and the way in which it is grasped, one can divide this [mental understanding] into five kinds: genus, species, difference, essence, and accident.

Therefore, when a universal [concept] originates in the said manner in the mind of a man because of his innate desire to know, he studies its [the universal's] condition through the use of reason. Knowledge about it [the universal] always derives from sensation, as does the notion which one has of this universal. Since one always arrives at a similar judgement about similar things, it so happens that one ascribes through thought a certain condition to a given subject, whether individual or universal, although one does not know through sensation that it [the condition] corresponds to it [the subject]. One does sense, however, that it [the subject] corresponds to something similar, and through this, the same correspondence is ascribed to what has been judged to be similar.

If, however, some individual or universal, or some condition is grasped in thought, but does not have a similar object of sensation, then such a notion is empty according to the human intellect, which by necessity originates from sensation.

Indeed, certain universals and their conditions are formed through reason, but not shown by sensation, as are certain kinds of powers which produce effects in bodies. For instance, the power of heating in fire can be grasped by reason, yet nothing similar to it can be perceived through sensation. Therefore, this power in itself cannot even be known through reason; rather, one can only imagine it [the power] because of its effect which can be perceived through sensation. [Only] in this sense can one say that this power is grasped by reason.

One ought to know that the same applies for individual things. For if things similar to them [the individual things] are not subject to sensation, the intellect which grasps an individual thing in this way is empty, even if it may appear to someone that the thing is grasped in this way.

It was somehow necessary, however, to give the human race the ability to form [i.e., to arrive at] a universal form from individual things, perceived through sensation in individual instances, since it is impossible to perceive all individuals. Yet, as some things can be sensed, it was necessary to derive the universal from a number of objects perceived by sensation. This universal would then somehow encompass all individual objects, so that, by knowing the universal, any individual object contained under this universal can be known, when it occurs to the senses. Man must know the universal, in order to know individual things which alone are useful for man, because they move, whereas universals never move. In this way the conditions of all things are first known through sensation: what, of what kind; of what size; acting and affected in what way; and how they relate to their own and other subjects, be they universal or individual.

Indeed, of both individual and universal things, as well as of their conditions, some are evident, some more evident, some most evident, others unclear, yet others more unclear, and yet others most unclear to both sensation and reason. The nature of these things effects this diversity by bringing them forth in a condition of one sort or another.

Some men are more, others less able to perceive either through sensation or reason. This is due to the individual ability of each one which enables him [to perceive] to a greater or lesser extent.

For this reason, some people become more knowledgeable than others. For when someone perceives things and conditions which are less perceptible, then he is, and is said to be, more knowledgeable. Therefore those imbued with a holy desire for knowledge strive most to understand the hidden condition of things.

Possessed of such a desire, the ancient fathers, when seeing with their bodily eyes the manifold diversity of the things in this world, investigated their origins and conditions with diligent and meticulous attention and perceived most things surrounding them through sensation. They even found through the exercise of reason many [other] things which are thought to lie beyond the realm of human understanding even by the philosophers of our time.

We believe that they achieved this owing to the balance of human nature [i.e., physical composition, such as the four humours] which was more perfect in them than in the others who share in the same [human] nature, and because they had acquired moral righteousness. Because of this [righteousness] and regular use of the things in which they were learned, [we believe that they] strove more inquisitively for things more capable to perfect them. Nor did they ever in their whole life cease in this striving and their zeal to know. It is in this way that they spent more [time and effort] on visible things which they thought to be supplied to them by the divine spirit rather than human reason.

For when they looked up, they saw the conditions of the many stars. Of those they tried above all to investigate and to know the properties of the seven planets, since they had established through long experience that they [the planets] were primarily responsible for arranging the things on earth. They thus acquired through sensation an unshakeable belief that the arrangement of the stars governed the world of elements and all things in it composed of them, at whatever time or place, to such an extent that no substance, no accident exists here without also being in its way figured in the sky. This [influence of the stars] is undoubtedly due to the rays sent from them [the stars] into the world.

Chapter Two – Each star has its own proper nature and condition comprising, among other things, how it sends out rays. Just as each and every star has its own special nature which cannot in its totality be found in any other star and which includes how it releases rays, so the rays themselves are of diverse natures in different stars, just as the stars themselves are of diverse natures.

For each star has its own position in the fabric of the universe, which is different from all the others. Therefore each star must possess a different aspect with regard to all other stars, all other things, and all other places contained in the universe.

A different aspect changes the effect of the rays, just as other differing properties in the stars also change the effect. It thus happens that each star produces a different effect, and in different ways, in different locations, and on different things, even if they vary only a little. For all stars produce these effects through the rays which vary among themselves with each different aspect.

For a ray which goes down from the centre of the star to the centre of the earth is proved to be the strongest in the kind of effect it produces. But those [rays] which fall obliquely, not directly down towards the centre of the earth, are weaker the more obliquely they fall. Unless, that is, they are strengthened by other rays meeting in the same location.

Each star emanates rays to each location. Therefore the various rays, as if fused into one, change the things contained in all the locations, as in each location the course of the rays is different, for it [the course] is determined by the overall harmony of the stars.

Moreover, as it [the harmony] constantly changes with the continuous movement of the planets and other stars, it [the harmony] constantly moves the world of elements [i.e., the sublunar world] and all the things contained in it in accordance with their location into varying conditions, being actualised as demanded at that time by the harmony, even if some things of this world seem to human sense to be unchanging. That this is not the case is proved quite clearly by physical reasoning—even if this [reasoning] has its origin in sense perception. It is therefore clear that all different locations and times produce different individual things in this world. This is achieved by the heavenly harmony through the rays sent into the world, as it [the harmony] constantly changes, and in certain cases, this is acknowledged by sense-perception.

The same thing can be grasped by reason, namely that the rays of the stars affect the same thing composed of elements differently according to the different nature of their [the stars'] components. The rays of the sun, for instance, lighten something dark—such as a human body—so that they bring about the colour on its surface through which they are also reflected. They [the rays] even make their heat enter the body and warm it. They even have a nearly life-giving nature; they strengthen man's spirit, and therefore it is likely that they exist in other things which are not so obvious to sense perception.

Therefore through reason one can conclude that the rays of all the different stars have different effects insofar as their own properties vary, since all things come to be and exist through rays.

But also the following should be noticed through thorough investigation: since each thing in this world constantly moves in a certain way, the form which it [the thing] receives through movement has as underlying matter [another] form which this thing lacks. For each form existing now is the matter of something which will exist next, and into which it is transformed through the movement of the rays of the stars which prevail over the thing with all its properties.

For this reason different underlying matter receives through movement a new form, that is, inasmuch as it is especially suitable to receive this form because of its proper nature. For this reason a harvest of wheat is produced by a seed of wheat rather than a harvest of barley in that spot. If one had sown barley seed there, a harvest of barley would have been produced through the same power of the rays which come together in this place. For although it [the power] is the same in any location, it brings about different effects insofar as the matter which exists [there] varies.

But know also this. The manners of men and habits of beasts change the underlying matter; it is as if part of it [the matter] is frequently found to be in the effect as well. For this reason the son of a king becomes king after his father's death, since the aptitude (habitus) to be inherited already exists in the seed. Its ethical qualities affect the son: he is born with the same aptitude which his father possessed. For this transition from such a matter to such a being produced of matter is an easy one. Quite frequently will the son of a craftsman be born as someone more apt for his father's profession, as the rays of the stars arrange the movement of this kind in matter.

The diversity of things visible in the world of elements at any moment in time is chiefly due to two causes: the diversity of matter and the diverse effect produced by the rays of the stars. Since the difference between these things is sometimes greater and sometimes smaller, those things produced [by them] differ more or less strongly at various locations and times. Therefore some things exist which differ in genus, some in species, but some only in number.

There is a greater variation in the underlying matter of things that differ generically than there is in the matter from which different species arise. Likewise, there is a greater variation in the matter of things naturally differing in species than there is in the matter used to produce individual things through natural movement; these differ in number only. In the same way when the rays of stars come together to produce in different places things which differ in genus, they are more different and diverse from one another in different places, than are [the rays] which produce things differing only in number.

This is the condition of the heavenly harmony, that all stars are of different natures, and therefore all their rays have different effects. Consequently, in the world of the elements, it occurs that the effects of the rays are helped by each other around one [kind of] matter, but hinder each other in another [kind of] matter. In each thing, that is, each thing produced by the harmony, a certain star predominates and likewise a certain sign which exerts its sway when acting upon, or ruling, this thing more than others.

Because of this mutual condition of the rays so much diversity comes about that hardly two or more things which actually exist in this world are found to be similar in all respects, even if human sensation is unable to grasp the difference. For when a kind of being is generated from a certain kind of matter through movements produced in this matter, as often happens, then people call this 'natural generation.' But when such a kind of being is generated from such a kind of matter in an unusual way, then one thinks that an unnatural generation has occurred. Yet in both cases the same heavenly harmony is at work: it acts at different places and times in such different ways that it sometimes produces like from like, sometimes divergent things. In certain things this happens frequently, in others only rarely, in yet others hardly at all, and in yet others never, insofar as man has experienced this. It [heavenly harmony] produces like [from like] sometimes through a similar movement, sometimes through a dissimilar one, sometimes through a slow movement, sometimes through a fast one, and in very many other ways.

The things in this world and their movements are found to vary in time and place. Since they have their origin in a heavenly cause, they in their totality or majority will lead the philosopher to wonder who knows the power of this cause. For if someone were able to understand the whole condition of the heavenly harmony, he would come to realise fully that the world of elements with all that is in it in any place and at any time is caused by a cause, as it were. Also, if he came to know something in this world to its full extent, then he would not fail to notice the condition of the heavenly harmony, as he understands the cause through

its effect. For each thing, however weakly it acts in the world of elements, is the effect of the entire heavenly harmony. Things, whether past or future, are marked down in the heavenly harmony, although [they are marked] differently than the things which actually exist at this time.

Therefore he who has discovered the whole condition of the heavenly harmony knows past, present, and future things. Conversely, the condition of an individual in this world, once fully known, shows, as if through a mirror, the whole condition of the heavenly harmony, as each thing in this world is an image of the universal's harmony.

Chapter Three – Well then, since the elementary world is the image of the world of stars so that each thing contained in the former possesses the appearance (species) of the latter, it is obvious that each thing in this world, whether substance or accident, produces rays in its own way like the stars; otherwise it [the world] would not be a complete likeness of the world of stars.

This can also be established by sensation in certain cases. Fire, for instance, conveys heat rays to adjacent places, and earth conveys rays of cold. Medical drugs, whether taken internally or applied externally, also are observed to spread the rays of their power through the body of the person who takes them. Furthermore, when bodies collide, they emit a sound which spreads itself everywhere, through the rays specific to them [the colliding things]; and each coloured object sends out its own rays through which one can see it. One knows this also in many other things through conjecture. Therefore it is seen to be firmly established through reason that this is true in all things.

Assuming this to be true we say that everything which actually exists in the world of elements sends out rays in all directions. These [rays] fill the entire world of elements in their own way. Hence each place in this world contains the rays of all the things which actually exist in it. Just as each thing differs from the next, so the rays of each thing differ in their effect and nature from the rays of all other things. For this reason the rays affect all the different things differently.

Furthermore, the distance of one thing from another makes a difference in the effect which the rays have on the things in this world.

Again, whether a location is more or less far away from the centre of the earth makes a difference in [the effect of] the rays on the bodies contained [in the location].

Again, whether an aspect is more or less oblique produces a difference in the effect of the rays. There are perhaps also other accidental things which introduce diversity into the effect of rays [emitted by] the things made of elements.

One ought to know that rays coming out of anything attain a different nature and a different effect, for the reasons given above. Therefore when different rays fall upon the same thing, they mix with each other. When they agree, the kind of effect is enhanced, but when they disagree, then their effect is diminished; or they influence each other in other ways by helping or hindering, as happens in the regions of the heavenly harmony. The difference in matter which receives the rays of other things made of elements makes a difference in the effect of these rays, as is the case with fire: it makes lead soft with the same rays through which it hardens a brick. This happens because of the difference of these [kinds of] matter.

One ought to pay attention to the fact that some rays are strong in a certain effect, whereas others are weak. In the same way, some are helped a lot in their effect by other rays of a different kind, but others are helped only a little by other [rays]. Likewise, some have roughly the same effect in different places and different matter, but others clearly have a different [effect]. Again, some have a great effect at one time, but a small effect at others. Likewise, some only wish to produce an effect in conjunction with many other [rays], and not otherwise, whereas for others a few suffice. They [the rays] have so many different modes that one can hardly express their diversity with words.

Yet some people were able to attain it [the diversity] in part, sometimes through experiments, and sometimes through reason first.

Some things, however, are still locked up in nature's treasure houses, that is to say, things which have not hitherto come to anybody's notice. For some of them man's ability to understand is not sufficient, whereas others can be known, but no mind has yet reached high enough to know them. Some [of these knowable things] are easier to perceive, but very few people have knowledge about them. Other things do not go

beyond the comprehension of average men. There are other things which are known to all, either through sensation only, or through both sensation and reason.

The effect of each thing made of elements and brought about through their rays occurs locally either together [with other rays], or separately.

One thing acts together with another when they are joined, either by touching each other or by neighbouring each other. Things which are thus joined

together act upon each other, and are acted upon by each other, through the influx of rays; they move each other according to the demand of nature which acts and is acted upon, as is obvious in many ways. These kinds of acts are discussed and defined by the discipline generally called physics.

Something made of elements acts on what is separated from it in place through the influx of the rays just as it does on what is touching it, although this [former] action does not appear to the senses as clearly as the latter; yet in certain cases even this [action] becomes clear to sensation as in the latter case [i.e., that of contact]. For one knows through sensation that a magnet attracts iron which is separate from it [the magnet]; and a mirror displays to the eyes the images of things which are separate from the mirror.

This can also be learned in many other instances through sensation. Therefore the philosophers transmitted a discipline about the effect which things made of elements have on other distant things.

Hildegard of Bingen, *Letter to to Guibert of Gembloux*

[...] From my early childhood, before my bones, nerves and veins were fully strengthened, I have always seen this vision in my soul, even to the present time when I am more than seventy years old. In this vision my soul, as God would have it, rises up high into the vault of heaven and into the changing sky and spreads itself out among different peoples, although they are far away from me in distant lands and places. And because I see them this way in my soul, I observe them in accord with the shifting of clouds and other created things. I do not hear them with my outward ears, nor do I perceive them by the thoughts of my own heart or by any combination of my five senses, but in my soul alone, while my outward eyes are open. So I have never fallen prey to ecstasy in the visions, but I see them wide awake, day and night. And I am constantly fettered by sickness, and often in the grip of pain so intense that it threatens to kill me, but God has sustained me until now.

The light which I see thus is not spatial, but it is far, far brighter which carries the sun. I can measure neither height, nor length, nor and I call it "the reflection of the living Light." And as the sun, the stars appear in water, so writings, sermons, virtues, and certain human take form for me and gleam within it. Now whatever I have seen or learned in this vision remains in my memory long time, so that when I have seen and heard it, I remember; and know all at once, and as if in an instant I learn what I know. But see, I do not know, for I am not educated but I have simply been read. And what I write is what I see and hear in the vision. I compose words than those I hear, and I set them forth in unpolished Latin them in the vision, for I am not taught in this vision to write as philosophers And the words in this vision are not like words uttered by the mouth like a shimmering flame, or a cloud floating in a clear sky. Moreover, more recognize the form of this light than I can gaze directly on the sun. Sometimes-but not often-I see within this light another light, "the living Light." And I cannot describe when and how I see it, but all sorrow and anguish leave me, so that then I feel like a simple girl old woman. But because of the constant sickness that I suffer, I sometimes get tired of writing the words and visions that are there revealed to me. Yet when my soul tastes and sees them, I am so transformed that, as I say, I forget all pain and trouble. And when I see and hear things in this vision, my soul drinks them in as from a fountain, which yet remains full and unexhausted. At no time is my soul deprived of that light which I call the reflection of the living Light, and I see it as if I were gazing at a starless sky in a shining cloud. In it I see the things of which I frequently speak, and I answer my correspondents from the radiance of this living Light

Grosseteste, *On Light*

The first corporeal form, which they name corporeity, I consider to be light. For by its nature light spreads itself in every direction in such a way that as large as possible a sphere of light is instantaneously generated from a point of light (provided nothing opaque stands in the way); while corporeity is that to which the

extension of matter in three dimensions is necessarily subsequent, despite the fact that both corporeity and matter are in themselves simple substances lacking any dimension. But a form that is in itself simple and lacking dimension could only introduce omnidirectional dimension into matter that is equally simple and without dimension by multiplying itself and instantaneously spreading itself in every direction and by extending matter in spreading itself, since form cannot leave matter because it is inseparable [from matter], and matter cannot be emptied of form.

But I have proposed that it is light to which this operation of multiplying itself and spreading itself instantaneously in every direction is essential; therefore, whatever engages in this activity is either light itself or else engages in it insofar as it is participating in light itself (which engages in it essentially). Corporeity is, therefore, either light itself or else engages in the aforementioned activity and introduces dimensions into matter insofar as it is participating in light itself and through the power of light itself. However, it is impossible that the first form introduce dimensions into matter through the power of a subsequent form; and so, light is not a form subsequent to corporeity, but is corporeity itself.

Furthermore, wise thinkers consider the first corporeal form to be more exalted than all subsequent forms and to have a more excellent and noble essence that is more like the forms that are separate [from matter].1 But light has a more exalted, excellent, and noble essence than all corporeal things, and more than any of them is like the forms that are separate [from matter], which are the intelligences. Therefore, light is the first corporeal form.

So light, which is the first form in created first matter, by its nature infinitely multiplying itself everywhere and stretching uniformly in every direction, at the beginning of time, extended matter (which it could not leave), drawing it out along with itself into a mass the size of the world-machine. Nor could the extension of matter be made by the finite multiplication of light, because the finite replication of that which is simple does not generate a quantum - as Aristotle demonstrates^ - but that which is simple must generate a finite quantum when infinitely multiplied (since the product of the infinite multiplication of something infinitely exceeds that from whose multiplication it is produced, and that which is simple is not infinitely exceeded by that which is simple but only by a finite quantum, for an infinite quantum exceeds that which is simple an infinitely infinite number of times). Light, then (which in itself is simple) must, when infinitely multiplied, extend matter (which is equally simple) into dimensions of finite size.

[...] Returning to my topic, then, I say that light by the infinite multiplication of itself made uniformly in every direction extends matter uniformly on all sides into a spherical form, with the necessary result that the outermost parts of this extension of matter are more extended and more rarefied than the innermost parts near the center. And when the outermost parts will have been rarefied as much as possible, the interior parts will still be capable of greater rarefaction.

[91-102] So, by extending first matter in the aforementioned way into a spherical form, and by rarefying the outermost parts as much as possible, light completed the possibility of matter in the outermost part of the sphere and did not leave it capable of further impression. In this way, the first body - which is called the firmament - was perfected at the extremity of the sphere, being composed of nothing but first matter and first form; thus, it is the most simple body in respect of the parts that constitute its essence and the greatest in quantity, and its only difference from the genus body is that the matter in it has been completed by the first form alone, whereas the genus body - which is in it and in other bodies - having first matter and first form in its essence, abstracts from the completion of matter by the first form and from falling short of the completion of matter by the first form.

So, having been completed in this way, the first body - that is, the firmament - spreads its luminosity out from all of its parts into the center of the whole. For, since light is the perfection of the first body and naturally multiplies itself incessantly, light of necessity is spread from the first body into the center of the whole. And being a substantial form inseparable from matter, in spreading itself from the first body light extends along with itself the spirituality of the matter of the first body, and in this way from the first body proceeds luminosity, which is a spiritual body or, as you may prefer to say, a corporeal spirit. And in its passage this luminosity does not divide the body through which it passes, and so it passes instantaneously from the body of the heaven all the way to the center. Nor are we to think of its passage as the passage of numerically one thing passing instantaneously from the heaven all the way to the center (for this may well be impossible); rather, its passage is through the multiplication and infinite generation of itself.

The luminosity, then, having spread out from the first body into the center and collected there, concentrated the mass existing below the first body. And the outermost parts of this mass had to be extended and dispersed as a result of this concentration, since, being complete and invariable, the first body now could not be lessened, and place could not be made empty. In this way a greater density arose in the innermost pans of this mass and the rarity was increased in the outermost parts. And so great was the power of the luminosity concentrating and, by this concentration, dispersing, that it thinned out and rarefied the outermost parts of the mass contained below the first body as much as possible. And in this way the second sphere came to be completed in the outermost parts of this mass and could undergo no further impression. Thus, the luminosity begotten from the first sphere is the completion and perfection of the second sphere, and light, which is simple in the first sphere, is doubled in the second.

Now, just as the luminosity begotten from the first body completed the second sphere and left a denser mass below the second sphere, so the luminosity begotten from the second sphere perfected the third sphere and by its concentration left an even denser mass below this third sphere. This concentration resulting in dispersal went on in this order until the nine celestial spheres were completed and a condensed mass, the matter of the four elements, was concentrated below the ninth and lowest sphere.

But this lowest sphere, which is the sphere of the moon, was also begetting luminosity from itself, and by its luminosity it concentrated the mass contained below itself and in concentrating it it thinned out and dispersed its outermost parts. Yet this luminosity did not have sufficient power to disperse the outermost parts as much as possible by its concentration, and accordingly in every part of this mass there remained imperfection and the possibility that it undergo concentration and dispersal.

And the highest part of this mass, though made fire by its dispersal, was not dispersed as much as possible and still remained elemental matter. And this element too, begetting luminosity from itself and concentrating the mass contained below itself, dispersed the outermost parts of it, though with a dispersal less than of fire itself, and in this way produced air. Air also, generating from itself a spiritual body (or corporeal spirit) and concentrating what is contained under itself, and, in concentrating it, dispersing its outer parts, produced water and earth. But because more of a power to concentrate than to disperse remained in water, water also remained heavy along with earth.

In this way, then, the thirteen spheres of this sensible world were brought into being, namely, the nine celestial spheres (which, being complete, are incapable of alteration, increase, generation, or corruption) and four spheres existing in a contrary manner (which, being incomplete, are capable of alteration, increase, generation, and corruption).

4. Light, Vision, and Colour in Metaphysics and Natural Philosophy

Texts:

1. Plato, *The Republic*, books 6 and 7 (excerpts). Transl. Reeve and Grube (Hackett, 1992).
2. Plotinus, *Enneads*, IV, 3, 17. Transl. Armstrong (Cambridge, 1984), 87-91.
3. Plotinus, *Enneads*, III, 6, 9. Transl. Armstrong (Cambridge, 1963), 245-249.
4. Solomon Ibn Gabirol, *Font of Life*, book 3, chapter 52 and book 4, chapter 18. Transl. Laumakis (Milwaukee, 2014), 179-80 and 211
5. Avicenna, *First Philosophy*, book 8, chapter 7. Transl. Marmura (Provo, 2005), 291
6. Grosseteste, *On Lines, Angles and Figures* (excerpt). Transl. Sparavigna ("On Lines, Angles and Figures," 2013), 102-3.
7. Roger Bacon, *On the Multiplication of Species*, book 1, chapter 1. Transl. Lindberg (Oxford, 1983), 3-21.

Plato, *The Republic*

Book 6: The Sun – Yes, I said, but I must first come to an understanding with you, and remind you of what I have mentioned in the course of this discussion, and at many other times.

What?

The old story, that there is a many beautiful and a many good, and so of other things which we describe and define; to all of them 'many' is applied.

True, he said.

And there is an absolute beauty and an absolute good, and of other things to which the term 'many' is applied there is an absolute; for they may be brought under a single idea, which is called the essence of each.

Very true.

The many, as we say, are seen but not known, and the ideas are known but not seen. Exactly. And what is the organ with which we see the visible things?

The sight, he said.

And with the hearing, I said, we hear, and with the other senses perceive the other objects of sense?

True.

But have you remarked that sight is by far the most costly and complex piece of workmanship which the artificer of the senses ever contrived?

No, I never have, he said.

Then reflect; has the ear or voice need of any third or additional nature in order that the one may be able to hear and the other to be heard?

Nothing of the sort.

No, indeed, I replied; and the same is true of most, if not all, the other senses --you would not say that any of them requires such an addition?

Certainly not.

But you see that without the addition of some other nature there is no seeing or being seen?

How do you mean?

Sight being, as I conceive, in the eyes, and he who has eyes wanting to see; colour being also present in them, still unless there be a third nature specially adapted to the purpose, the owner of the eyes will see nothing and the colours will be invisible.

Of what nature are you speaking?

Of that which you term light, I replied.

True, he said.

Noble, then, is the bond which links together sight and visibility, and great beyond other bonds by no small difference of nature; for light is their bond, and light is no ignoble thing?

Nay, he said, the reverse of ignoble.

And which, I said, of the gods in heaven would you say was the lord of this element? Whose is that light which makes the eye to see perfectly and the visible to appear?

You mean the sun, as you and all mankind say. May not the relation of sight to this deity be described as follows?

How?

Neither sight nor the eye in which sight resides is the sun?

No.

Yet of all the organs of sense the eye is the most like the sun?

By far the most like.

And the power which the eye possesses is a sort of effluence which is dispensed from the sun?

Exactly.

Then the sun is not sight, but the author of sight who is recognised by sight.

True, he said.

And this is he whom I call the child of the good, whom the good begat in his own likeness, to be in the visible world, in relation to sight and the things of sight, what the good is in the intellectual world in relation to mind and the things of mind.

Will you be a little more explicit? he said.

Why, you know, I said, that the eyes, when a person directs them towards objects on which the light of day is no longer shining, but the moon and stars only, see dimly, and are nearly blind; they seem to have no clearness of vision in them?

Very true.

But when they are directed towards objects on which the sun shines, they see clearly and there is sight in them?

Certainly.

And the soul is like the eye: when resting upon that on which truth and being shine, the soul perceives and understands and is radiant with intelligence; but when turned towards the twilight of becoming and perishing, then she has opinion only, and goes blinking about, and is first of one opinion and then of another, and seems to have no intelligence?

Just so.

Now, that which imparts truth to the known and the power of knowing to the knower is what I would have you term the idea of good, and this you will deem to be the cause of science, and of truth in so far as the latter becomes the subject of knowledge; beautiful too, as are both truth and knowledge, you will be right in esteeming this other nature as more beautiful than either; and, as in the previous instance, light and sight may be truly said to be like the sun, and yet not to be the sun, so in this other sphere, science and truth may be deemed to be like the good, but not the good; the good has a place of honour yet higher.

What a wonder of beauty that must be, he said, which is the author of science and truth, and yet surpasses them in beauty; for you surely cannot mean to say that pleasure is the good?

God forbid, I replied; but may I ask you to consider the image in another point of view?

In what point of view?

You would say, would you not, that the sun is only the author of visibility in all visible things, but of generation and nourishment and growth, though he himself is not generation?

Certainly.

In like manner the good may be said to be not only the author of knowledge to all things known, but of their being and essence, and yet the good is not essence, but far exceeds essence in dignity and power.

Glaucon said, with a ludicrous earnestness: By the light of heaven, how amazing!

Yes, I said, and the exaggeration may be set down to you; for you made me utter my fancies.

And pray continue to utter them; at any rate let us hear if there is anything more to be said about the similitude of the sun.

Yes, I said, there is a great deal more. Then omit nothing, however slight.

I will do my best, I said; but I should think that a great deal will have to be omitted.

Book 7: The cave – And now, I said, let me show in a figure how far our nature is enlightened or unenlightened: --Behold! human beings living in a underground den, which has a mouth open towards the light and reaching all along the den; here they have been from their childhood, and have their legs and necks chained so that they cannot move, and can only see before them, being prevented by the chains from turning round their heads. Above and behind them a fire is blazing at a distance, and between the fire and the prisoners there is a raised way; and you will see, if you look, a low wall built along the way, like the screen which marionette players have in front of them, over which they show the puppets.

I see.

And do you see, I said, men passing along the wall carrying all sorts of vessels, and statues and figures of animals made of wood and stone and various materials, which appear over the wall? Some of them are talking, others silent.

You have shown me a strange image, and they are strange prisoners. Like ourselves, I replied; and they see only their own shadows, or the shadows of one another, which the fire throws on the opposite wall of the cave?

True, he said; how could they see anything but the shadows if they were never allowed to move their heads?

And of the objects which are being carried in like manner they would only see the shadows?

Yes, he said.

And if they were able to converse with one another, would they not suppose that they were naming what was actually before them?

Very true.

And suppose further that the prison had an echo which came from the other side, would they not be sure to fancy when one of the passers-by spoke that the voice which they heard came from the passing shadow?

No question, he replied.

To them, I said, the truth would be literally nothing but the shadows of the images.

That is certain.

And now look again, and see what will naturally follow it' the prisoners are released and disabused of their error. At first, when any of them is liberated and compelled suddenly to stand up and turn his neck round and walk and look towards the light, he will suffer sharp pains; the glare will distress him, and he will be unable to see the realities of which in his former state he had seen the shadows; and then conceive some one saying to him, that what he saw before was an illusion, but that now, when he is approaching nearer to being and his eye is turned towards more real existence, he has a clearer vision, -what will be his reply? And you may further imagine that his instructor is pointing to the objects as they pass and requiring him to name them, -will he not be perplexed? Will he not fancy that the shadows which he formerly saw are truer than the objects which are now shown to him?

Far truer.

And if he is compelled to look straight at the light, will he not have a pain in his eyes which will make him turn away to take and take in the objects of vision which he can see, and which he will conceive to be in reality clearer than the things which are now being shown to him?

True, he now.

And suppose once more, that he is reluctantly dragged up a steep and rugged ascent, and held fast until he is forced into the presence of the sun himself, is he not likely to be pained and irritated? When he approaches the light his eyes will be dazzled, and he will not be able to see anything at all of what are now called realities.

Not all in a moment, he said.

He will require to grow accustomed to the sight of the upper world. And first he will see the shadows best, next the reflections of men and other objects in the water, and then the objects themselves; then he will gaze upon the light of the moon and the stars and the spangled heaven; and he will see the sky and the stars by night better than the sun or the light of the sun by day?

Certainly.

Last of he will be able to see the sun, and not mere reflections of him in the water, but he will see him in his own proper place, and not in another; and he will contemplate him as he is.

Certainly.

He will then proceed to argue that this is he who gives the season and the years, and is the guardian of all that is in the visible world, and in a certain way the cause of all things which he and his fellows have been accustomed to behold?

Clearly, he said, he would first see the sun and then reason about him.

And when he remembered his old habitation, and the wisdom of the den and his fellow-prisoners, do you not suppose that he would felicitate himself on the change, and pity them?

Certainly, he would.

And if they were in the habit of conferring honours among themselves on those who were quickest to observe the passing shadows and to remark which of them went before, and which followed after, and which were together; and who were therefore best able to draw conclusions as to the future, do you think that he would care for such honours and glories, or envy the possessors of them? Would he not say with Homer, Better to be the poor servant of a poor master, and to endure anything, rather than think as they do and live after their manner?

Yes, he said, I think that he would rather suffer anything than entertain these false notions and live in this miserable manner.

Imagine once more, I said, such an one coming suddenly out of the sun to be replaced in his old situation; would he not be certain to have his eyes full of darkness?

To be sure, he said.

And if there were a contest, and he had to compete in measuring the shadows with the prisoners who had never moved out of the den, while his sight was still weak, and before his eyes had become steady (and the time which would be needed to acquire this new habit of sight might be very considerable) would he not be ridiculous? Men would say of him that up he went and down he came without his eyes; and that it was better not even to think of ascending; and if any one tried to loose another

and lead him up to the light, let them only catch the offender, and they would put him to death.

No question, he said.

This entire allegory, I said, you may now append, dear Glaucon, to the previous argument; the prison-house is the world of sight, the light of the fire is the sun, and you will not misapprehend me if you interpret the journey upwards to be the ascent of the soul into the intellectual world according to my poor belief, which, at your desire, I have expressed whether rightly or wrongly God knows. But, whether true or false, my opinion is that in the world of knowledge the idea of good appears last of all, and is seen only with an effort; and, when seen, is also inferred to be the universal author of all things beautiful and right, parent of light and of the lord of light in this visible world, and the immediate source of reason and truth in the

intellectual; and that this is the power upon which he who would act rationally, either in public or private life must have his eye fixed.

I agree, he said, as far as I am able to understand you.

Moreover, I said, you must not wonder that those who attain to this beatific vision are unwilling to descend to human affairs; for their souls are ever hastening into the upper world where they desire to dwell; which desire of theirs is very natural, if our allegory may be trusted.

Plotinus, *Enneads*

Ennead IV, 3, 17 – One could deduce from considerations like the following that the souls when they leave the intelligible first enter the space of heaven. For if heaven is the better part of the region perceived by the senses, it borders on the last and lowest parts of the intelligible. So these heavenly regions are first ensouled thence, and participate in soul first because they are better adapted to participate. But the body of earth is the last, and less naturally adapted to participate in soul and far from the bodiless nature. All souls then illuminate the heaven and give it the greatest and first part of themselves, but illuminate the rest of the world with their secondary parts; those which come down further throw their light lower, but it is not to their advantage to have gone on so far. For there is a kind of centre, and around this a circle shining out from it, and beyond these another, light from light: but outside these there is no longer another circle of light but this next circle through lack of its own light needs illumination from another source. Let this be a wheel, or rather a sphere of a kind which from the third—for it borders upon it—obtains all the illumination which that third receives. So the great light abides and shines, and its radiance goes out through the world in rational order and proportion; the other lights join in illuminating, some staying in their places, but others are more attracted by the brightness of what is illuminated. Then as the things which are illuminated need more care, just as the steersmen of ships in a storm concentrate more and more on the care of their ships and are unaware that they are forgetting themselves, that they are in danger of being dragged down with the wreck of the ships, these souls incline downwards more with what is theirs. Then they are held fettered with bonds of magic, held fast by their care for [bodily] nature. But if every living creature was like the All, a perfect and sufficient body and in no danger of suffering, then the soul which is said to be present would not be present in it, and would give it life while remaining altogether in the upper world.

Ennead III, 6, 9 – One must, of course, understand first of all that there is not only one way in which one thing is present to another or in another; but there is one way in which the presence of the thing goes with an improvement or deterioration in the other which involves change; this is the kind of presence which is observed in bodies, living ones at any rate; and there is another which brings about improvement or deterioration without the other being affected; this is what we have said happens in the case of the soul. There is another way, too, which is like what happens when someone impresses a shape on wax, where there is no affection, so as to make the wax into something else when the shape is there, and there are no deficiencies when the shape is gone. And light, certainly, does not even produce an alteration of shape in the thing illuminated. And when a stone becomes cold, what does it get from the coldness, since it remains a stone? And in what way could a line be affected by colour? I do not think that even a surface could be. But, perhaps, the body underlying it could? Yet how could it be affected by colour? For one must not call presence or putting on a shape "being affected." If one said that mirrors and transparent things generally were in no way affected by the images seen in them, he would be giving a not inappropriate example. For the things in matter are images too, and matter is still less liable to affections than are mirrors. For certainly heats and coldnesses occur in it, but they do not heat it; for heating and cooling belong to quality, which brings the substrate from one state to another. (But we should consider whether coldness is not an absence and a privation.) But when the qualities come together in matter most of them will act upon each other, or, rather, those will which are opposed to each other. For what could fragrance do to sweetness or colour to shape, or a filing which belongs to one kind to a thing of another kind? This would very much confirm one's belief that it is possible for one thing to be in the same place as another, or in another, without troubling by its presence that with which or in which it is. So then, just as a thing does not suffer injury from any and every chance encounter, so that which is changed and affected is not affected by anything and everything, but it is opposites which affect opposites, and other things remain unchanged by each other. Those, then, in which there is no opposition could not be affected by any opposite. So that, if

anything is affected, it cannot be matter but must be a composite or in general a multiplicity of things all together. But that which is " single and set apart " from all other things and in every way simple would be unaffected by everything and set apart in the midst of all the things which act on each other; just as when people are hitting each other in the same house the house is unaffected, and so is the air in it. So let the things which have matter as their substrate act on each other as it is their nature to do, but let matter itself be unaffected, much more so than those qualities in it which are unaffected by each other because they are not opposed.

Solomon Ibn Gabirol, *Font of Life*

Book 3, chapter 52 – S: The simple substances have now been made certain according to the methods that you divulged. But at this point, a doubt about them still occurs to me when I consider our statement that the forms sustained in the substance sustaining the categories are impressed by simple substances and derived from them. I apprehend that the intellect is ready to understand this, and it is not prevented from conceding this because of the demonstrations presented earlier that prove this. For these forms are accidents, and nothing prevents their being derived from the simple substances and joined with them like the flowing forth of the suns light from the sun and its union with bodies. But how shall I say that some simple substances flow from others and that the essence of the substance sustaining the categories flows from the simple substance that follows it in rank?

T: The essences of the simple substances have not flowed down, but it is their powers and rays that flow down and are poured out. For the essences of each n of these substances are finite and limited, not extended to infinity. But their rays flow from them and go beyond their boundaries and limits because of their inclusion under the first flowing, which flows forth from the will. This is like the light that flows forth from the sun into the air, because this light goes beyond the boundaries of the sun and is extended through the air, while the sun in itself does not go beyond its own limit. And it is also like the animal power that flows forth from the rational power, whose seat is the brain, into the nerves and muscles, because this power penetrates and is spread through all parts of the body, while the soul's substance in itself is neither spread out nor extended. , Similarly, any simple substance extends its own ray and light and spreads them on that which is lower, while in doing this the substance still retains its rank and does not go beyond its own limit.

S: According to this statement, then, it is necessary chat the things that flow from the simple substances are powers and qualities, not substances themselves.

T: I will make it clear to you that the rays that flow from each of the substances are not outside of the concept of substantiality, although they are powers, because they flow from them. I say that it must be necessary that a cause is more worthy of the concept of substantiality than an effect. Since this is so, it is necessary that the whole light that flows from a higher to a lower thing is not truly and perfectly worthy of the concept of substantiality according to its relation to the first substance, which is its cause. According to this consideration, it will be said about these substances that they are diverse in the certitude of the concept of substantiality. Therefore, the higher among them will be more worthy of this than the lower.-But although the lower is not equal to the higher in the concept of substantiality, it is still not outside of the concept of substantiality, because there flows from it a power that is a substance for that which flows from it. Therefore, a lower substance is in one respect a power for the higher substance from which it flows, and it is in another respect a substance for the power that flows from it. Because of this, nothing prevents that a substance flows from a substance, when it is a simple substance from which it flows.

Book 4, chapter 18 – T: Since these forms are similar, is it not necessary that some of them flow down from others, as was said earlier, and that the more perfect and stronger among these substances is the cause of the imperfect and weak?

S: This must be so.

T: Since the forms of simple and composite substances are infused in their essences, encompassing whatever belongs to them, although these forms flow down, one from another, that is, the lower from the higher, consequently from the highest end all the way to the lowest end, why do you not see that form is infused in all forms like the infusion of the sun in the air, and is stretched out from the highest all the way to the lowest by a continuous extension and that it already filled up universal matter and encompassed it,

and no part of universal matter and no place is empty and stripped of it but is clothed by it? But its orders are diverse in matter, because the light from it was pure in the highest end, and b the substance that sustains it was subtle and spiritual. Similarly, the light from it was extinguished, darkened, and cloudy in the lower end, and the substance that sustains that light was thick and corporeal, And the things in between the extremes were according to the change of light and the thickness of matter in proportion to their distance and nearness. Hence, when you consider form in this way, you will see that it begins as perfect and spiritual, and it subsequently gradually becomes thick until it reaches the lowest extreme. You will then see here motion stopping and form at rest.

Avicenna, *First Philosophy*

Book 8, chapter 7 – Furthermore, it must be known that when it is said of the First, "intellect," it is said in the simple sense that you have known in the Psychology, that in Him there is no variety of forms arranged and differing, such as there is in the [human] soul, in the sense previously [discussed] in the Psychology. For this reason He intellectually apprehends things all at once, without being rendered multiple by them in His substance, or their becoming conceived in their forms in the reality of His essence. Rather, their forms emanate from Him as intelligibles. He is more worthy to be an intellect than the forms that emanate from His intellectuality. Because He intellectually apprehends His essence, and that He is the principle of all things, He apprehends [by] His essence all things.

Know that the intelligible meaning may be derived from the existing thing, as happens when, by astronomical observation and sensation, we ourselves apprehend from the celestial sphere its intelligible form. The intelligible form, however, may not be taken from the existent, but conversely—as, for example, [when] we intellectually apprehend the form of a building which we invent and this intelligible form moves our organs until we bring about its existence. Thus, it would not have [first] existed and then were intellectually apprehended it, but [first] we intellectually apprehended it and then it existed. And this is the relation of the whole to the First Intellect, the Necessary Existent. For He intellectually apprehends His essence and what His essence necessitates. He knows from His essence the manner in which the good comes to be in all [things]. Thus, the form of the existents follows the intelligible form He conceives in the intelligible order [which is conceived by] Him, [but] not in that it follows it as light follows that which gives light and warming [follows] heat. Rather, He knows the manner in which the order of the good [takes place] in existence and that it [proceeds] from Him; and He knows that existence emanates from this act of knowing, according to the ranking that He intellectually apprehends as good and as order.

Grosseteste, *On Lines, Angles and Figures*

The utility of considering lines, angles and figures is huge, because it is impossible to know the philosophy of Nature without them. They are valid for the entire universe and, unconditionally, for all its parts. They apply in connecting properties, such as in straight and circular motions. And they apply in action and passion (reaction), and this is so, whether in the matter or in the capacities of perception; and this is so again, whether in the sense of sight, as it is occurring, or in any other sense in the action of which it is necessary to add on other things to that which is producing the vision. Then, since we have discussed elsewhere of those things pertaining to the whole universe and to its parts in an absolute sense, and of those which are consequent to straight and circular motions, now we have to tell something concerning the universal action, when it is receiving a lower nature; this universal action is a player able of various features, so far as it happens when it is descending to act in the matter of the world; moreover, other things can be questioned, that can educate us to proceed "ad majora".

Therefore, all the causes of the natural effects must be given by lines, angles and figures, because it is impossible to know in another manner the "propter quid" in them. It is clear the following: a natural agent propagates (multiplies) its power from itself to the patient, the person or thing that undergoes some action, that is, whether it is acting on sense or on matter. This virtue is sometimes called "species", sometimes "likeness", and it is the same, in any way we call it; and the same thing is instilled in the sense and in the matter, or vice versa, when heat makes warm to the touch and gives itself to the cold body. For, it does not act through deliberation and choice; and therefore in one way it acts, whatever it is occurring, whether it is a perception or something else, animated or inanimate. But, because of the diversity of the objects of action we have different effects. Moreover, in the perception, this received power produces, in some way, a

spiritual and noble effect; on the other hand, when acting on the matter, it produces a material effect, such as the sun produces, through the same power, different effects in different objects of its action, because it hardens the clay and melts the ice.

Moreover, the power produced by a natural agent can move along a shorter line, and then, it is more active, because the patient receiving it is less distant from the agent, or it can move along a longer line, and then it is less active, because the patient is more distant. And the power can come directly from the surface of an agent, or with mediation. Moreover, if it comes without mediation, it can come by a straight line, or by an oblique line. If, however, it comes by a straight line, then there is a stronger and better action, as Aristotle assumes in V Physics, because the nature acts in the shorter available way. But the straight line is the shortest of all, as he says in the same book. Similarly, a straight line has equality and no angles; but equal is better than unequal, as Boethius tells in his Arithmetic. And Nature acts in the possible shorter and better way, and therefore it works better on a straight line. Again, every compact power is stronger in its operations. But, the greater union and unity is in a straight line rather than in distorted line, as stated in V Metaphysics. And then an action works stronger on a straight line.

The straight line can fall either at equal angles, that is perpendicular to the surface, or at unequal angles. If it falls at equal angles, the operation is stronger for the three abovementioned reasons, because the line is shorter and equal and its power comes more uniform through it to the parts of the patient, person or thing that undergoes the action. A line, however, is falling down with equal angles on a body perpendicularly, that is with right angles, when it falls on a plane; when it falls on a concave body, it is at acute angles; but when it is falling over a sphere, it happens at angles larger than the right angle. This is shown as in the following, because, if a line is drawn passing through the center of a sphere, it makes a right angle with the line of contingency (tangency), and the line of tangency makes with the sphere on both sides the angles of contingency; then, the line falling on the sphere makes two angles with its surface, each angle larger than the right angle, being the sum of the right angle and the angle of contingency. Thus, when the power falls with angles which are not only equal, but right, then it would seem the action to be very strong, because there is complete equality and uniformity. If, however, it is not a straight line but it is a curve, nevertheless, not circular, because a natural agent does not produce its own strength according to a circle, but according to the diameter of the circle for the sake of brevity, it is manifest that such a line will have some angles. And this will not occur, as long as there is a single medium, or while there is only one body; but it is necessary that two media exist, whence in the first the power is propagated along some straight lines, and in the second along other lines.

This can happen only in two manners. First manner: that the body of the patient is dense, so as to impede the transit of power, especially in regard to our perception, and then it is said we have a reflected line, which is turning back the power. Second manner: the body the light is passing through is thin in density, which allows the propagation of power. If we have the first case, then we have the ray falling on a dense body, it falls with equal angles, that is, perpendicularly to the body, or with unequal angles, that is inclined. If we have the first manner, then it returns into itself through the same path, along which it arrived to the body. The reason of this is due to the following: the line falling on the body makes such an angle, as it is the angle made by the reflected line. And therefore it is proper that it is reflected at the same angle, upon which the ray travelled and return by the same pattern, because if it were redirected with another angle or following another pattern, turning to the left or to the right, it would be impossible that the return forms an angle equal to the angle of incidence; it would be larger or smaller. In the case that the ray is not falling perpendicularly, then it comes back along such a pattern, able to make an angle with the surface of the resisting body equal to the angle of incidence, namely, the angle which is made by the incident line with that body, for the argument already mentioned. Generally speaking, the angle of incidence and the angle of reflection are equal, and that is to be assumed now.

Since these are the two modes in which reflection may happens, it is to be understood that the reflected power into itself, because of a doubling of the power in the same place, is stronger than the reflected power in another path. Nevertheless, and this is in the essence of reflection, the action of the reflected ray is weaker, when there is the reflection in the same path, since each reflection is weakening the power, and this precise reflection, which is making the power to have a complete deviation of 180° from the straight prolongation of the incident ray (that is, the direction the ray would have if it were to pass through the body), is highly weakened; and this is for the ray, which is moving on the same path on which it came from. Moreover, the path is totally contrary and opposed to the incident one, as it must be.

Roger Bacon, *On the Multiplication of Species*

Book 1, chapter 1 – Now the first chapter concerning the influence of an agent has three truths or conclusions. The first conclusion considers what this influence is according to name and essence. Accordingly, it should be recalled that in the third part of this work it was mentioned that essence, substance, nature, power, potency, virtue, and force signify the same thing, but differ only in relation. For 'essence' is considered with respect to itself, 'substance' with respect to accident, the others in reference to the eliciting of an action. But 'nature' means an aptitude for acting, apart from any further inclination. 'Potency' and 'power' mean the same thing, and they are commonly applied to either a complete or an incomplete operation. 'Virtue' and 'force' also mean the same thing, but they are applied only to that which completes an operation. And I speak here concerning a potency that elicits an action, rather than that which accomplishes an action. For the latter is in the second species of quality, while that which elicits [an action] belongs to [the class of] all active things; and these are substances and the proper sensibles, unless there is an exception in sound, as we shall explain below.

'Virtue' is taken in another way, as the first effect of the aforementioned virtue, because of its similarity to this [other] virtue in both essence and operation, since it is similar to it in definition and specific essence; and consequently it is similar to it in operation, since things of similar essence have similar operations. And this second virtue has many names, for it is called 'the similitude of the agent', 'image', 'species', 'idol', 'simulacrum', 'phantasm', 'form', 'intention', 'passion', 'impression', and 'shadow of the philosopher's' by authors of works on vision.

By 'species' we do not here mean Porphyry's fifth universal; rather this name is meant to designate the first effect of any naturally-acting thing. And to explain this meaning of 'species' with an example, we say that the lumen of the sun in the air is the species of the solar lux in the body of the sun; and lumen hilling, perchance, through a window or an aperture is sufficiently visible to us, and it is the species of the lux of a star. And Avicenna says in *De anima*, book iii, that lux is a quality of a luminous body, such as fire or a star; but lumen is that which is multiplied and generated from that lux and which is produced in air and other rare bodies, which are called media because species are multiplied by their mediation. Nevertheless, we usually employ lux and lumen interchangeably. And when a ray passes through a medium of strongly-coloured glass or crystal or cloth, there appears to us in the dark, in the vicinity of the ray, a colour similar to the colour of that strongly-coloured body; and tills colour in an opaque substance [that intercepts it] is called the 'similitude and species' of the colour in the strongly-coloured [transparent] body through which the ray passes.

Moreover, [the aforementioned second virtue] is called 'similitude' and 'image' with respect to the tiling generating it, to which it is similar and which it imitates. It is called 'species' with respect to sense and intellect, according to the use of Aristotle and the naturalists, for Aristotle says in *De anima*, book ii, that sense universally receives the species of sensible things, and in book iii he says that the seat of species is the intellect. It is called 'idol' with respect to mirrors—for thus we frequently employ the term. It is called 'phantasm' and 'simulacrum' in the apparitions of dreams, since these species penetrate sense as far as the interior parts of the soul and appear in dreams as if they were the things of which they are [in fact only] apparitions, since the apparitions resemble the things; and the soul is not able to judge as well during dreams as when awake, and therefore it is deceived, judging the species to be the things themselves of which they are species, on account of the resemblance. It is called 'form' by Alhazen, author of the widely known *Perspectiva*. It is called 'intention' by the multitude of naturalists because of the weakness of its being in comparison to that of the thing itself, for they say that it is not truly a thing, but rather the intention, that is, the similitude, of a thing. It is called 'shadow of the philosophers', since it is not clearly sensible except in the two instances mentioned, namely, of a ray falling through a window and of a strongly-coloured species; and the expression 'of the philosophers' is employed because only skilful philosophers know the nature and operation of this shadow, as this treatise will make clear. It is called 'virtue' with respect to generation and corruption, and therefore we say that the sun extends its virtue into the matter of the world for producing generation and corruption; and thus we say that every agent produces its virtue in a recipient. It is called 'impression' because it resembles impressions; thus Aristotle, in *De anima*, book ii, compares the generation of a species to the impression made in wax by a signet ring or seal, although the two are not similar in all respects, as will be shown later. It is called 'passion' because the medium and sense, in receiving

species, undergo a transmutation in their substance; however, this transmutation is towards perfection and well-being, unless there should be more than a solitary species, as will be better expounded later.

Therefore, we must investigate the essence of a species; and since our intention is to show that this species is similar in essence and definition to the agent and the thing generating it, we must first set forth what all must acknowledge, namely, that a species is the first effect of an agent; for all judge that through species [all] other effects are produced. Thus the wise and the foolish disagree about many things in their knowledge of species, but they agree in this, that the agent sends forth a species into the matter of the recipient, so that, through the species first produced, it can bring forth out of the potentiality of the matter [of the recipient] the complete effect that it intends. And therefore, there is no doubt that the species is the first effect. But that this first effect of any natural agent is similar to the agent in specific essence, in nature, and in operation is evident from things to be said below; for the agent directs its efforts to making the recipient similar to itself, because the recipient, as Aristotle intends in *De generatione*, is always potentially what the agent is in actuality, as he there asserts. And at first, before the action, the recipient is of itself dissimilar to the agent, and through the action it becomes similar, as Aristotle says; and when the agent acts on the recipient, it at once assimilates the latter to itself and makes the recipient to be such as the agent is in actuality, as Aristotle says. And therefore, if fire is the agent, it produces fire; if heat, heat; if light, light; and so for all things. But this can occur better in the first and immediate effect than in the secondary and mediated; therefore, the former, especially, will be made to resemble the agent. Hence, it must be posited that the virtue or species produced by an agent is similar to the agent in nature, definition, specific essence, and operation. Likewise, every diversity can be traced back to identity; and duality descends from unity and not vice versa. And therefore, the first effect of an agent cannot differ from it in specific essence while subsequently giving rise to a [further] effect similar [to the agent] and uniform [with it]; for thus diversity would be the source of unity, which is contrary to nature.

Moreover, the effects of light are these, namely, its species and light generated in the medium, heat, putrefaction, and death; for this order is followed when a thing is corrupted. But we see that the third degree of an effect is further from the nature of the agent than is the second; and therefore the second is further than the first, if they are not essentially and numerically the same. And this is what we intend. Accordingly, the species of light is light, although at first incomplete and afterwards completed in things in which this is possible, as in the moon and stars, which can retain light.

Likewise, if the species of fire is not similar to fire in nature, essence, and definition (so as to belong to the same lowest species as fire), then it will not belong to any category—which is impossible —since it cannot be in the categories of accidents, because there is no way of telling to which category [of accidents] it should be assigned, Nor could the first effect be so removed from its agent as to pass into another category, for nobody can say that the species of whiteness or light passes into another category. And therefore the species of fire cannot do so, especially since fire is said to be generated by means of this species, for no accident is the source from which substance is generated; nor can [the species of fire] be of [the same nature as] water or air; nor can it belong to some lowest species of substance, or a subordinate species, as is evident. Therefore it must be in the same species as fire. Nor does anybody claim that there is something between substance and accident, since the metaphysician proves that there can be no such intermediate thing. And therefore it cannot be said that [the species or similitude of fire] is reduced to a lowest species of fire, so that it would be in the same genus and the same lowest species only by reduction, for everything has a certain essence and nature, b\' virtue of which it is necessarily a determined substance or an accident; and therefore of itself it is classified as some kind of thing, belonging to a certain category and a certain genus and a certain lowest species.

Also, in Ptolemy's *De opticis* or *De aspectibus*, book ii, it is declared that colouring and illumination come to the medium and the eye from colour and light. But there can be no colouring except through the being of colour, nor illumination except through the being of light. And we learn this by observation; for a solar ray falling through a window is visible to us, and it alters sight primarily and by itself; and since this is not colour, it must be true light, for only light and colour are suited to alter sight primarily and by themselves. Similarly, when we observe rays penetrating strongly-coloured glass, we sensibly observe the colour in an opaque body near the glass, and the colour sensibly and by itself alters vision; and yet we know that what alters vision is the species and similitude of the colour of the glass. Therefore, the species of colour is colour, and the species of light is light, and similarly for all things. Thus a species agrees with its agent in nature and definition. And therefore Aristotle says in *De anima*, book ii, that the recipient of colour and

sound and every sensible, such as the medium or the sense organs, is of itself uncoloured and soundless and lacking the nature of sensibles— meaning by this that the medium and sense receive colour and sound as they receive the species of colour and sound, and similarly for the other species of sensible things. And therefore the species of which we here speak is similar to the agent in specific nature and in definition.

If, against this, it is objected that the species of the sun would then be sun and the species of man would then be man, and similarly for all things (which would be utterly absurd), we reply that the names 'man', 'sun', 'ass', 'plant', and the like are imposed for things that have complete being and not for things that have incomplete being, even though both are of the same essence; thus the embryo in the mother's womb is not called 'man', especially before it receives the rational soul. Nevertheless, after the animal essence is transmuted and pushed onward to the point where it becomes a human species, it is necessary for that which develops beyond the essence of the genus, before infusion of the rational soul, to possess the nature of man, since it is suited to receive a rational soul and not the soul of an ass or anything else. Therefore, we do not say that it is man, and yet it does belong to the same species as man according to incomplete being. We say the same thing concerning the species of man (that is, man's similitude produced by man in the air), for it is not man, since it has the most incomplete being that can be found in the species of man, far more incomplete than that of the embryo before the reception of the rational soul; for the embryo can achieve the perfection of man, whereas the species of man cannot. And it must be recognized that some things, such as heat, light, colour, and the like, can give rise to strong species, as will be explained below. But the nobler things are (such as celestial bodies and man and the like), the more incomplete are their species, the cause of which will be given below; and therefore the species of colour, light, and heat are more appropriately called 'colour', 'light', and 'heat' than is the species of the sun or man called 'sun' or 'man'. Nevertheless, the species will always be of the same specific nature, but under being that is very incomplete and incapable of being completed, and therefore it does not receive the name that is applied to the more complete being.

From this follows a second truth: that there can be only one effect having an essence similar to that of the agent; and this is called 'the first effect' and a 'univocal effect', and its generation is said to be univocal. There can be many other effects, and they are called 'equivocal effects', and their generation is said to be equivocal; thus heat, putrefaction, and death are several effects of light, and they are not univocal, but equivocal. For only lumen in the medium, or lux in the body of a star produced by the lumen of the sun, is called a univocal effect of the solar lux. But at first, while it is an incomplete effect, it is called 'species' and 'virtue' and the aforementioned names; and this is while the recipient maintains its specific nature, although it is made to resemble the agent through that species and virtue; thus wood, when first ignited, receives the species and virtue of fire while still retaining its own specific nature as wood, although it is made to resemble fire through the received species. However, when the agent prevails over the recipient, so as to corrupt and destroy the specific nature of the recipient, and thus to introduce into the matter its own complete effect, agreeing both with it and with the recipient, as occurs in generable and corruptible things, then the effect ceases to be called 'species' and 'virtue' and the other names mentioned above and is called by the name of the agent itself. Thus when fire prevails over wood and corrupts the specific nature of the wood, introducing the complete essence of fire, then what is generated is called 'fire' and not 'species' or 'virtue', whether charcoal or flame results; and therefore complete fire and the species of fire differ only as the complete and the incomplete. Therefore, it is numerically one and the same effect that is first called 'species', while it has incomplete being, and then, when its being is complete and the total specific nature of the recipient has been destroyed, receives the full name of the agent and source. And it is to be understood that this is true of corruptible terrestrial things.

In incorruptible things a certain species can easily be developed into a complete effect without destruction of the recipient, since the recipient is naturally adapted to such an effect, as the stars and moon are suited to possess perfect light in the quantity required by their nature, although the sun has more light. And thus the species of light first reaches the moon and the stars and is afterwards perfected in them, as it was at the first creation and as occurs after stellar eclipses. For at first they have weak light, as though a similitude and species, and afterward clear and perfect light. The evidence for this is that the moon is red when eclipsed, since it receives light only when it is outside the shadow; however, while it is within the shadow it has a weak species of light coming from the light that passes outside, along the sides and edges of the shadow, as will be explained more fully later. Nevertheless, it must be known that the species of the sun, which is of the same specific nature as the sun, cannot be perfected in the moon and stars (although it comes to be in them), since that would require the moon and stars to become the sun, which is impossible; for light is

a common quality of the sun and stars and fire, although the sun has more of it [than do the others]; and therefore the species of light can be perfected in the moon and stars, while the species of the substance of the sun cannot, since the sun, moon, and stars differ in specific substance, as will be evident below. And light does not share in their substance; but it is an accident common to them and to fire, although some people are accustomed to claim that light is the substantial form of the sun and stars; but this is false.

Having now asserted these things, we demonstrate them as follows: if there are two effects altogether similar to the agent, but altogether distinct numerically—that is to say, not one effect, which at first is incomplete and afterwards (remaining the same in number) is completed —then (to put the matter numerically) when the agent acts on one part of the recipient there will be in that part of the recipient two forms belonging to the same species. But this is not possible, since form appropriates to itself and numbers the particular matter in which it is; and then [if there could be such numerically distinct effects], there would be two fires in the same part of burning wood, which, for the reason given, cannot be. And again, since the second form would be useless, because one form would suffice to perfect the matter in which it is, it follows that the additional one is superfluous. But nature does nothing superfluously or uselessly except through error, as in monsters and mistakes of nature, which will not be treated here.

However, it should be recognized that although a species is similar in name and definition to that which generates it, as the species of fire in air or wood, nevertheless it is more properly and intelligibly said that air and wood are assimilated to fire through the species than that an individual of fire is present there; for an individual of air or wood actually exists there in its specific nature, and therefore two individuals are not present there (speaking numerically), namely, one of air and another of fire, but one absolutely, namely, of air, which has complete being; and therefore the latter prevails in this place and gives its name to the individual. Yet this individual of air is assimilated to fire (in its fiery nature) through the species of fire present in it; and therefore this individual is called 'ignited air', for it is not only air and not only fire and not principally fire, but principally air, only ignited; and therefore such fire as is there is an incomplete individual of fire, existing in another more complete [substance], which predominates and more justly supplies the name. And therefore [with] much less [justification] would we say that an individual of man or of the sun or of some other noble thing is present in air; rather, we will say that air is assimilated to man or the sun through a species, which nevertheless has the same specific nature as man or the sun and is classified under it, although according to being that is very incomplete and incapable of completion, as will be taught below. And through this very incomplete being the individual of air is said to be assimilated to the sun; but there is no assimilation between an individual of air and an individual of sun, for the name comes from the complete being.

But if, against this truth and the previous one, it is stated that Aristotle says in *De sensu et sensato* that colour exists only in a mixed body,36 and similarly odour, flavour, and the like, and therefore that there can be no colour in air or in [other] simple elements and bodies, it is replied that colour, odour, flavour, and the like cannot exist in air and simple bodies according to complete being, but according to incomplete being. And again it can be conceded that in so far as air and other simple bodies receive the being of colour and effects of this kind, which exist naturally in mixed bodies, to that extent they receive the being of a mixture; for an agent that can alter the air to [the state of] colour can alter it to [the state of] being mixed, so that in simple air the species of whatever mixture you wish would come into being as required by the species produced in the air by such effects as colour, odour, and the like. For air is in potentiality to mixture, and a completed mixture can come into being from it, and therefore much more easily can it be altered to the being of a mixture in the degree required by the species of the mixture.

It is to be known, in the third place, that an agent naturally produces the same first effect (that is, species) in whatever it acts upon, because for its part it acts uniformly; for only an agent that possesses free will and acts by deliberation can, for its part, act difformly. But a natural agent possesses neither will nor the ability to deliberate, and therefore it acts uniformly. Also, if an agent possessing will, such as man, should act in a natural mode in generating species, to that extent it will act uniformly and (so far as it is concerned) in one way, since nature and a natural mode have the same mode [of action]; and therefore, whatever recipient it meets, it always produces the same first effect. Therefore, whether it acts on sense, on its contrary, or on matter proportioned (and not contrary) to it, it can produce only a species, whether complete or incomplete, because it produces no other first effect. Thus heat, whether it acts on the sense of touch or on a cold thing contrary to it, always produces only the species of warmth as its first effect. And if the sun should act on terrestrial things that are not its contraries, it will similarly produce only a species, no matter how different

from, and contrary to, each other these terrestrial things are. Likewise, if a thing acts on the intellect, it will produce only its species, just as when it acts on sense or on its contrary, But how, in general and in particular, species are produced in various recipients, both spiritual and corporeal, will be revealed below.38 Here, though, I deal with recipients only from the standpoint of the agent producing in them the same first effect, no matter what recipient it acts upon.

And since indeed a natural agent, for its part, acts in one way, and this for every agent that acts by nature or in a natural mode, therefore, when warmth produces different effects in a cold body and in the sense of touch, this must be the result of diversity in the recipients, just as sun by the same virtue melts wax and hardens mud. And from this we can refute the error of those who judge that the agent sends one thing into sense and another into its contrary, meaning that a species is produced in sense while some other virtue is produced in the agent's contrary; for they say that warmth corrupts cold but, provided it is not excessive, does not corrupt sense. For Aristotle says in De anima, book ii, that tire action [of an agent] on its contrary' corrupts, while action on sense is beneficial and perfects; and sense delights in a sensible species, while the contrary is always injured and corrupted in part or in whole. And although in sense there is some suffering and injury owing [even] to a sensible proportioned as closely as you please [to the sense organ], according to the authors of books on optics, and especially Alhazen in *De aspectibus*, book i, nevertheless there is simultaneously a pleasure that prevails over the suffering and injury, which is not [so] in the contrary. And therefore, [the holders of the erroneous opinion] supposed that one thing is received by sense and another thing by the contrary; but this is impossible, according to the aforesaid. And our view is confirmed by Aristotle in *Physics*, book vii, where he says that 'whatever the natural agent, alteration and being altered occur in sensible things'; but the agent produces in sensible things only that effect which is suited to alter sense, and this is a species; therefore, in the natural action of every natural agent, only a species is produced.

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