Chapter 12

On the difference between bodies as regards their extent and persistence.

91. There are two properties in every body that have magnitude, and are therefore capable of being measured, namely its extent and its persistence, from which latter the amount of matter is estimated that is assigned to a body.

Since according to the first general property every body has extent, and since extent is of the genus magnitude, every body can be measured as to its extent to determine how much bigger or smaller its extent is than that of another body, from which we judge the size of a body. Geometry teaches how to measure the size of a body in certain measures such as cubic rods, feet or inches; also when we talk of the quantities related to bodies, one considers in the first instance their actual size or extent. Later we have seen that we can also measure the persistence, which one must consider the bigger or the smaller in one body than in another, depending on the larger or the smaller the required force is that will produce in its state the same change in the same time; and from this measurement arises the amount of matter that is assigned to a body. From this it is easy to understand what we mean by saying that in a body there is just as much or twice as much matter as in another. If one imagines two spheres of equal size, one of gold and one of silver, then these two bodies are equal as regards their extent or actual size; but it is certain that the gold sphere contains a far greater amount of matter than the silver one; the ratio of the amount of matter in the golden sphere to that in the silver one is nearly 19 to 11. The impenetrability does not itself yield a magnitude, i.e. we cannot say that one body is more or less impenetrable than another; all are impenetrable to the highest degree, which implies to the same degree.

92. The more matter is contained in a given extent, the denser is a body, and one finds the density of a body by dividing its matter by its size. But one notices in different bodies a large difference in density.

Here we must in particular bear in mind the distinction between the proper and the foreign matter in a body. We call the *proper* matter of a body the matter that moves together with the body, and the persistence of which must be overcome if one wants to change the state of the body; since the amount of matter is judged from the force that is necessary to produce a given change in the body in a given time, only all that matter must be assigned to the body, the state of which must be changed if one wants to change the state of the body. But in every body there are a number of pores or hollows, of which one cannot yet say whether or not they are filled with some matter. As the following investigations will show, if they do contain some matter, then it is frequently so subtle and volatile, that it is not subject to the changes that take place in the body, but, being able to move freely through the pores, does not take part in the changes of the body. This is the abovementioned *foreign* matter, which occupies a part of the body's extent, but

does not contribute to its persistence and amount of matter. One can look on such a body as a vessel, penetrated through and through in all directions by holes, and this vessel is to be moved under water; since the water not only fills all the holes, but can also flow freely through them, the body can be moved without it being necessary to impart the same motion to the water in the holes, and for this reason the water would have to be regarded as a foreign matter in the body. Nevertheless it cannot be denied that the water will take some part in the motion of the body, and that this would require some force, resulting in an increase in the proper matter. But whether for the same reason the subtle matter present in its pores does increase the proper matter of a body, will be examined in more detail below.

93. If we understand by the true size of a body only that part of its extent that is filled by its proper matter, thus excluding the pores in which there is either nothing or foreign matter, then the true density will result if one divides its proper matter by its true size.

It is therefore necessary to distinguish between the true size of a body and its apparent size, which latter is estimated from the space occupied by the body including its pores. Therefore the true size of a body is always smaller than the apparent one, and the difference is the size corresponding to all the pores. Similarly one must distinguish between the true density of a body and its apparent density; for although in both cases only the proper matter is taken into consideration, this must in the first case be divided by the true size, and in the second case by the apparent size; since the true size is smaller than the apparent one, the true density must be accordingly larger. It could also be the case that for all bodies the true density would be the same. This would be so if the bodies only were apparently more or less dense because they contained fewer or more pores. Although for example gold is much denser than wood, their true density could be the same if in wood there were that many more pores than in gold. Experiments do in fact show that in a body that is less dense there are far more pores and therefore, if both bodies have the same apparent size, the true size of the less dense one would have to be much smaller than that of the denser one. If this is correct, then it follows at the very least that the true density in bodies generally can not be as different as the apparent density. But further below it will be shown by convincing arguments that in all bodies on earth with which we can make experiments, the true density is the same. These arguments are based on the fact that in all bodies the weight is proportional to the true size and also proportional to the quantity of proper matter, so that our conclusion is valid for all heavy bodies.

94. Although it seems highly probable that in all bodies the true density is of the same magnitude, one can not maintain this regarding the subtle matter that fills the pores of bodies, since otherwise no movement could take place in the world.

Although we can see no reason why in all bodies the ratio of the proper mass to the true size should be the same, the above considerations regarding the true density of bodies

makes this view very probable. For when all coarser bodies have the same true density, then there almost seems to be a necessity based on the essence, due to which in every body this and no other ratio should occur between the true size and the amount of matter. If we wanted to maintain this also with regard to the subtle matter in the pores of bodies, it would follow that the entire space of the world were filled with equally dense matter, the density of which would have to be even bigger than the apparent density of gold. For if one does not want to admit that the pores of bodies are completely empty, which cannot be the case, then it does not matter whether this subtle matter fills the air or the coarser bodies, since both would have the same density. In this space no body could move without pushing out of the way as much matter as it encounters according to its true size; one would thus have the case where a body is to move through liquid matter that has the same density as the body; but it has been shown that because of the astonishing resistance no movement could then occur, or it would at least have to cease again at once. If one wanted to argue that this matter were itself in motion, and would tear the body along, then this would only be valid for bodies that move at the same speed and in the same direction as the matter; but since we know that a body can be moved in all directions and even, if no coarser matter is present, meets practically no resistance, this view about the same true density of all bodies can not be maintained.

95. It is therefore necessary to maintain that the pores of bodies are either entirely empty, or that the matter contained therein has a density many thousand times smaller than the proper matter of which the coarser bodies of this earth consist.

If one wanted to say that the pores of bodies are entirely empty, one would encounter all the arguments that are leveled against empty space, but in particular, since it will be shown beyond doubt that all bodies are pressed from all sides by a subtle matter, at least this matter would enter into the pores. But if we side with those who deny all empty space, then we must of necessity admit that the subtle matter in the pores has a density many thousands times smaller than the coarser bodies of this earth; whoever has learned to calculate the resistance encountered by bodies moving in liquid matter, will admit this without difficulty. It is only necessary to consider the movement of a body in a space free of air, which, as experience teaches, suffers no discernible resistance: but this space must be filled with a subtle matter (it is irrelevant whether this is the same matter that is found in the pores of bodies or some other matter; since it is a question what kinds of subtle matter, apart from the coarser bodies, actually exist in the world); and since the body encounters in it a far smaller resistance than in air, whose apparent density is about 20000 times smaller than that of gold, the true density of subtle matter must be at least 100000 times smaller than the true density of bodies on this earth. If one wanted to say this space, as well as the pores of bodies, were in part empty and only in part filled with subtle matter, assuming the empty part not to be 100000 times bigger than the other filled part, then one would have to admit that the density of subtle matter would have to be far less than that of the bodies. This can also be demonstrated without the Theory of Resistance; for if the pores were filled with such an astonishingly dense matter, however liquid one might assume it to be, it would not be possible for a body to move and change its state

without at the same time to change the state of this matter, which would require additional forces, contrary to experience.

96. There are thus at least two main kinds of matter in the world, a coarse one and a subtle one. The coarse matter has a certain and unchangeable degree of density, which is even greater than the apparent density of gold; against this the density of subtle matter is many thousand times smaller.

Since the proper matter of all coarse bodies has the same density, there is no doubt that this degree of density should not be due to the particular essence of this matter. Whether another similar matter would be possible, having a greater or smaller density, we do not dare to decide here; it is however most remarkable that the true density of all bodies on which one can experiment is found to be the same, since these bodies show such a variety in all respects, that one tends to exclude all similarity. But how great the dissimilarity may be, it is certain that as regards true density they are absolutely the same. However such a definite value of must not be due to the essence of bodies, so that no other value were possible, since we have shown that the subtle matter that fills the pores of bodies and all remaining space not occupied by coarser bodies, has a density many thousand times smaller. Since this matter does also really exist, and must because of its properties be regarded as a body, we must concede two types of matter to exist in the world, the coarse and the subtle, whose main difference consists in the fact that one, namely the coarse one, has a density of a certain value, which is even greater than the apparent density of gold; the subtle one on the other hand has a density many thousand times smaller. Whether there are several kinds of this subtle matter, some of which are denser than others, we shall not be discussing here, but if indeed there are several kinds, we shall refer to them collectively as subtle matter. As long as the explanation of what occurs in nature does not require several such kinds, it would be bold and against the rules of a sound Science of Nature if, merely following our imagination we were to increase the number of kinds of subtle matter.

97. All bodies in the world consist of these two types of matter, the coarse and the subtle, and all differences between them arise from the different mixing and composition of these two types of matter.

It is rightly maintained that all bodies cannot possibly consist of a single type of matter; for since one cannot admit an empty space, all bodies would have the same density, and there would be no difference between them other than their shape, but even that would not be there, because all bodies would touch one another, forming nothing other than a lump of matter of just one type. To explain the great variety of bodies, some teachers of Natural Science have considered all particles making up bodies to be different from each other, which would require an infinite number of types of matter to exist. But the jump from one single type of matter to an infinitely large number is too great, and it should at least have been necessary to show first that two types of matter are not sufficient to bring about the differences between the bodies. Since we have already stated, and will explain

even further below, that all coarse matter has the same density, an infinite variety amongst the particles of this matter does not occur; and since our two kinds of matter can be mixed and compounded in an infinite number of ways, it is easy to see that through this process the variety we observe in the bodies of the world can come about. It all depends on the quantity, size and arrangement of the pores, that are distributed between the coarse parts of every body, and of these there is a variety that is indeed infinite; this explains easily how it is possible that not two bodies are similar in all respects; since the Creator had a particular intention for each body, it is most probable that its composition from coarse and subtle matter should be different; in this intention the principle of not differentiating may well exist; and when this principle is properly interpreted, it meets with no difficulty from the similarity of coarse matter.