From Leibniz's Exchange with Johann Bernoulli

(a) From Leibniz to Johann Bernoulli, 7/17 June 1698: (A III 7, 796-97).

I gather from [Varignon]'s response that you have written certain profound and ingenious things to him about the variously infinite bodies.[1] It seems to me that I understand your meaning, and have often deliberated about these matters, but have not yet dared to pronounce on them until now. Perhaps the infinite and infinitely small that we conceive are imaginary, but suitable for determining real things, just as roots are also usually considered imaginary. They are those things in ideal reasonings by which real things are regulated as if by laws, even though they are not among the parts of matter. But if we posit infinitely small real lines, it follows that we must also posit straight lines bounded at both ends, which are nonetheless to our ordinary lines as infinite to finite; assuming this, it follows that there is a point in space which cannot ever be reached from here in any assignable time by an equable motion; and similarly we will need to consider a time bounded at both ends which is nonetheless infinite, and thus there will be a certain kind of eternity, so to speak, that is bounded; ôr, it would be possible for someone to live in such a way that he would die after a number of years that is not ever assignable, and yet he would die at some time—all of which I would not dare to admit, unless forced to do so by indubitable proofs. The real infinite is perhaps the absolute itself, which is not made up of parts, but comprises parts by having an eminent reason and, as it were, a degree of perfection. If there were something perfectly rigid, and perfectly equable, they would be held to be just as we conceive them in our geometry, but I am afraid nature does not allow this. Meanwhile I praise the force of your genius, willing to root out the most abstruse things. If we get the opportunity to speak together, perhaps you would hear from me many marvels more concerning the universe and principles that I take as demonstrated. Now, farewell and prosper.

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[1] Cf. Pierre Varignon to Johann Bernoulli, 27 May 1698, in *Der Briefwechsel von Johann I Bernoulli mit Pierre Varignon, Erster Teil: 1692-1702,* ed . by P. Costabel and J. Pfeiffer, Springer, Basel 1988, N. 36, p. 173. Varignon refers to Bernoulli's letter of 20 May 1698, see N. 35 esp. 169-72: " je crois effectivement que le monde est infini mais relativement, et que s'il n'y en a pas, il peut toujours y en avoir sans contradiction d'autres infiniment plus grands montans par tous les degrez d'infinite, et d'autres infiniment plus petis descendant par tous les degrez d'infinite; et que ce n'est que le MONDE des mondes, c'est à dire l'UNIVERS (qui comprend tous ces mondes si vous voulez imaginaires ou chimeriques, il m'importe peu comme vous les appellerez) qui est l'infini des infinis, c'est à dire l'infini absolu en etendue. Or c'est cet infini absolu qui est l'effet le plus convenable à la Cause souveraine ou infinie absolue en perfection, c'est à dire au Createur" (p. 171). This letter was forwarded to Leibniz by Bernoulli in his letter of 31 May/10 June 1698 (A III 7, N. 200, 786ff).

(b) From Johann Bernoulli to Leibniz, 5/15 July, 1698 (A III, 7, 810)

You have come near enough to my opinion on the variety of infinities. And I do not assert for certain that there are infinite degrees of infinities, rather I only adduce conjectures, by which I have stated the matter to be possible and probable.[2] And indeed I have offered a reason for this to be so, that there is no reason why God would have wished there to exist only this degree of infinity ôr this kind of quantity which constitute our objects and are proportionate to our intellect; when, however, I can easily conceive that there could exist in the least speck of powder a world in which everything would be in proportion to this large one, and on the other hand our world could be nothing other than a speck of powder in another infinitely larger one; and that this conception could be continued in ascending and descending without end, whence our kind of quantities would make only one of an infinity of degrees. But there is nothing which might persuade me that this should exist rather than that, for whatever reason could be adduced for one would be applicable to any other degree. So, for example, if I were to conceive in a drop of air a formed world having parts proportional to those in ours, sun, stars, planets, the Earth with its inhabitants, and all other quantities in the same ratio, then what is for us the tiny time of one second, for them would be a series of many ages, and so on for the others. Meanwhile these people could use the same arguments to prove that only they exist, that their world is infinite, and that nothing exists outside it. But I should break off, for if I wished to recount here even to myself all my sweet deliriums by which I sail through these infinities, many pages would not be enough for me.

(c) From Leibniz to Johann Bernoulli, 12/22 July, 1698 (A III, 7, 827-28)

From the actual division it follows that in however small a part of matter there is a kind of world consisting of innumerable created things; but that still leaves open to question whether there will be any portion of matter which has an unassignable ratio to another portion; ôr, whether there will be a straight line bounded at both ends, but which nonetheless has a ratio to another straight line that is infinite or infinitely small. In the calculus we usefully assume this, but from this it does not follow that they can exist in nature. Therefore the matter needs to be investigated further.

[2] Cf. once again Johann Bernoulli to Pierre Varignon, 20 May 1698, Briefwechsel, N. 35, p. 169. The editors of A III 7 refer to Bernoulli's letter to Varignon, 24 December 1697, N. 31, where, however, Bernoulli hints at this topic at p. 153.

(d) From Johann Bernoulli to Leibniz, 23 July/2 August, 1698 (A III 7, 847-48)

I am surprised that you ask "whether there could be any portion of matter which would have an unassignable ratio to another portion; ôr, whether there could be a straight line bounded at both ends, but which nonetheless has a ratio to another straight line that is infinite or infinitely small", since you nonetheless admit the actual division of matter into parts infinite in number. For if a finite body has parts infinite in number, I always believed and still do believe that the least of these parts must have an unassignable ôr infinitely small ratio to the whole. And there is no need for an actual division, it suffices that such a particle co-exists with the whole it is in, just as a mathematical line co-exists with a surface or the surface with a body, or whatever differential with its integral; or, as I say more fittingly, just as according to Harvey and others, though not according to Leeuwenhoek, in innumerable animals there are little eggs, in any egg an animalcule or several, in every (female) animalcule in turn innumerable little eggs and so on to infinity.[3] But whatever my thoughts may be on the infinity of worlds, I have not meant to sell them as certain and demonstrated, but rather as mere probable conjectures; having tried with this fundamental principle, that their existence implies no contradiction, because our thought, inasmuch as it is only relative concerning the infinite as well as the finite, because it is nothing in itself, and as neither large nor small, so neither infinite nor finite, and because finally there is no argument against the infinity of worlds which could not equally well be used by the inhabitants of another world to demonstrate that they alone exist. But perhaps an occasion will arise for me to explain these things more thoroughly.

(e) From Leibniz to Johann Bernoulli, 29 July/8 August, 1698 (A III 7, 857-858)

But between ourselves, I would also add this, that I also once wrote in the said unpublished manuscript[4] that it is possible to doubt whether there could be infinitely long straight lines that were nonetheless also in fact bounded. Meanwhile, it suffices for the calculus that they be taken as fictions [*fingantur*], like imaginary roots in algebra. For it is always the case that what is concluded by means of the infinite and infinitely small can be evinced by a *reductio ad absurdum*

[3] Bernoulli is referring to the ovist interpretation of the theory of preformation, according to which the preformed embryo was placed in the female egg, which was contrasted by the spermist (or animalculist) view, defended by Leeuwenwhoek, according to which the preformed individual was located in the male semen. Cf. Smith 2011, 178-84.

[4] Leibniz refers to his 1676 treatise De quadratura arithmetica circuli, ellipseos et hyperbolae, now available in A VII 6, 521 ff.

by my method of incomparables (the Lemmas for which I gave in the Acta)[5]. So you also shouldn't wonder that I doubt whether there is an infinitely small thing, or an infinitely great one bounded at both ends. For even though I concede that there is no portion of matter that is not actually cut, one does not on that account come to uncuttable elements, or minimum portions, nor indeed to infinitely small things, but only to ones perpetually smaller, and yet ordinary; similarly in increasing one comes to perpetually greater ones. Thus also I easily concede that there are always animalcules in animalcules, and yet that it is necessary that there are not infinitely small animalcules, still less ultimate ones. If I were to concede such things as the infinite and the infinitely small that we are discussing to be possible, I would also believe them to exist.

(f) From Johann Bernoulli to Leibniz, 16 /26 August, 1698 (A III 7, 873-74)

I do not remember ever having said that in the division of matter it is possible to arrive at uncuttable elements or to minimum portions. But here it is not a question of how far I can reach in a division, whether an actual or a mental one, it is a question of how far it has already reached. You concede a finite portion of matter already actually divided into parts infinite in number, and yet you deny that it is possible for one of these particles to be infinitely minute, how is that coherent? For if there is no infinitely minute one, then the individual particles are finite, if they are all finite then taken together they constitute an infinite magnitude, contrary to hypothesis. Conceive a determinate magnitude divided into parts in this geometrically decreasing progression, 1/2, 1/4, 1/8, 1/16, 1/32, etc.: whenever the number of terms is finite I admit that the individual terms will also be finite, but if all the terms actually exist, the infinitieth and all subsequent terms will certainly be of infinitely small magnitude. But in any body, because of the infinite division actually made, not about to be made, all the terms of the progression really and actually exist. Therefore, etc. Moreover, a body which by being moved describes a line, at any rate actually exists at each of the individual points I can conceive in that line, and therefore also in two points that I conceive infinitely close to one another; and so that infinitely minute interval or particle is traversed. And finally, although such an infinitely small particle could not exist separately, nonetheless it coexists with the whole. But I am surprised that you say that if you were to concede that such infinite and infinitely small things as we are discussing were possible, you would

[5] Tentamen de motuum coelestium causis, in Acta Eruditorum, February 1689 (in Leibniz: Journal Articles on Natural Philosophy, Text 10, pp. 95-111: §5, pp. 99-100)

concede that they also exist. I wish then that you would demonstrate their impossibility to me. For just as I do not simply attribute to myself the possibility of proving their existence, so on the other hand I am most persuaded that its impossibility cannot be shown by any arguments.

(g) From Leibniz to Johann Bernoulli, 22 August/1 September 1698 (A III 7, 884-885)

Like De Volder, Gregoire de Saint–Vincent once said somewhere that the axiom that the whole is greater than the part does not hold in the infinite.[6] But it seems to me that one of two things must be said, either that the infinite is not really one whole, or that, if the infinite is a whole and yet is greater than its part, then this is something absurd. Indeed, many years ago I demonstrated that the number or multiplicity of all numbers implies a contradiction, if it is taken as one whole.[7] It is the same with the greatest number or the least number, or with the least of all fractions. And the same should be said about these as about the fastest motion, and similar things.

Also the Universe is not one whole, nor should it be conceived as an animal whose soul is God, as the ancients held. But just as there is no numerical element, ôr least part of unity or minimum in numbers, so there is no least line, ôr lineal element; for a line, like Unity, can be cut into parts or fractions. On the other hand, I accept that since the maximum is different from the infinite, and the minimum from the infinitely small, this does not immediately refute the possibility of our infinitely small things. And they can at least be used in calculation and reasoning, which, as I have already observed, is not permissible with the maximum and unbounded, or with the minimum.

When I said that if I believed infinitely small things were even possible, I would have conceded that they exist, I did not on that account say they were impossible, but left the matter somewhere still in the middle. When I denied that we arrive at minimum portions, it could easily be judged that I was speaking not [just] about our divisions, but also about those that actually occur in nature. So even though I hold for certain that any part of matter is again actually subdivided, I do not however think that it follows from this that there is an infinitely small portion

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[6] The editors of A III 7 refer to Gregory of St. Vincent's *Opus Geometricum*, 1647, p. 871. On De Volder, see Bernoulli to Leibniz, 16/26 August 1698, A III 7, N. 219, 872.

[7] Accessio ad arithmeticam infinitorum, end of 1672, A III 1, 10-13.

of matter, and still less do I concede that it follows that there is any absolutely minimum portion. Anyone who wants to reduce this argument to its form, will feel the difficulty.

But you say, "if there is nothing infinitely minute, then all individual things will be finite." (This I concede.) "If all individual things are finite, then all of them taken together will constitute an infinite magnitude." I do not concede this consequence. I would concede it if there were some finite thing which was smaller than all others, or certainly greater than no other; for then I agree that if one assumes a greater plurality of such things than any given number, there arises a quantity greater than any given. But it is well known that for any given part there is another smaller finite one. You use an example ~~would of course appreciate an example~~ very appropriate to the matter.

Let us suppose that in a line its 1/2, 1/4, 1/8, 1/16, 1/32, etc. parts are actually given, and that all the terms of this series actually exist. You infer from this that there also exists an infinitieth term. I, on the other hand, think that nothing follows from this other than that there actually exists any assignable finite fraction, however small you please. Similarly in motion, even though it passes through all the points, it still does not follow that there are two points infinitely near to one another, and even less does it follow that they are next to one another. And in fact I conceive points, not as elements of a line, but as limits or negations of further progress, or as endpoints of lines.

(h) From Johann Bernoulli to Leibniz, 6 /16 September, 1698 (A III, 7, 899-900)

At this very hour I am about to leave town, so I cannot respond to the contents of your letter as extensively as I would wish. I will say this at least: I also believe that there is no maximum or minimum quantity; infinite and infinitely small things cannot be demonstrated to exist, but also that it is not possible to demonstrate their nonexistence; nonetheless, it is probable that they exist. If all the terms of this progression, $^1/_2$, $^1/_4$, $^1/_8$, $^1/_{16}$, $^1/_{32}$, etc., actually exist, *then*[8] *an infinitieth term exists, as do all the terms which succeed it*, it seems to me one can rightly infer this from actual existence. Nor do I conceive points as elements of a line, but only as limits.

[8] Over this Leibniz has written: "supposing there is an infinitieth, and others following it. But this I do not admit"

What you understand by primary matter[9] *per se*, ôr by *bulk* as distinct from secondary matter ôr mass, I do not grasp well enough, nor also what is to you incomplete[10] if secondary matter ôr mass is not *a substance* but *substances*. If indeed you are comparing it with a flock or a pond, then divide for me a certain portion[11] of matter into its single or individual solitary substances, as a flock is divided into animals, or an army into soldiers, etc., and clearly explain, I ask you, what such a single substance consists in. Let there be something[12] analogous to a soul. You concede no portion of matter to be so very small that there does not exist in it an infinity of such souls, such substances, such monads, or by whatever name you want to designate them. Then how far should this proceed until I reach a simple unity[13], single and individual? —in order for me to say, "here is a substance, not *substances*"? Certainly, matter will have to be divided not only into infinitely small parts, but into minima, that is, into points[14] or into non-quanta [unquantified parts], which do not exist.

(i) From Leibniz to Johann Bernoulli, 20/30 September 1698 (A III, 7, 908-9)

I come now to what in your most recent letter are metaphysical considerations. You infer as follows: "If all the terms of this progression, $^1/_2$, $^1/_4$, $^1/_8$, $^1/_{16}$, $^1/_{32}$, etc., actually exist, then an infinitieth term and those following it also exist." I reply that the inference is good, if it is conceded that there really is an infinitieth term, or post-infinitieth, but this is the very thing that I do not concede.

You ask, 1) what I understand by matter per se, ôr prime matter ôr bulk, as distinct from secondary matter. I reply: that which is merely passive, and separate from souls or forms.

You ask, 2) what is incomplete for me here? I reply: the passive without the active and the active without the passive.

3.) You ask me to divide for you a portion of matter into the substances from which it is composed: I reply that there are in it as many individual substances as there are in it animals ôr

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[9] Over this Leibniz has written: "primary matter is merely passive, ôr does not involve souls"

[10] Over this Leibniz has written: "form without matter or matter without form"

[11] Over this Leibniz has written: "in a mass there are as many substances as animals or living things, or things analogous to them"

[12] Over this Leibniz has written: "Souls alone do not constitute single substances, animals do"

[13] Over this Leibniz has written: "Every animal [is constituted] by a true substance, even if <its> organic body <properly> consists of substances".

[14] Over this Leibniz has written: "Matter is no more composed out of animals than out of points"

living things ôr things analogous to them, and so in the same way as I divide, for instance, a flock or a fish-pond, except for what liquid is interjected between the animals in the flock or the fish, and likewise the liquid (indeed, also the rest of the mass) contained in each fish or animal, I judge must be divided again like a new fish-pond, and so on into infinity.

4.) I call a complete monad ôr a singular substance not so much a soul as the animal itself, or an analogue to it endowed with a soul ôr form and an organic body.

5.) You ask how far we should proceed in order to have something that is a substance, not substances. I reply that such a thing is offered straightaway without subdivision, and that any one animal whatever is such a thing. For I, you, he, are not composed of the parts of our body.

6.) You are afraid that body would be composed of non-quanta [unquantified parts]. I reply that it is no more composed of souls than of points.

The more you inquire the more you will see the connection and solidity of the view, finally established not by a fitful consideration, but after a lengthy proposal and retraction over a long time; and perhaps at some point you will approve these metaphysical reflections no less than the dynamics.

(j) From Johann Bernoulli to Leibniz, 8/18 November 1698: (A III 7, N. 242, pp. 935-39).

I do not disapprove of your metaphysical reflections, and readily admit them and your dynamics, provided only that you provide me with a clear idea of them. Your responses on this score are too laconic, and are definitions rather than explanations. It seems to me a contradiction to say that all the terms of this progression, $^1/_2$, $^1/_4$, $^1/_8$, $^1/_{16}$, etc. exist, but that there really are no infinitieth terms: for if infinitieths do not exist, then the terms are only finite, therefore not all the terms exist, contrary to hypothesis. I see indeed what you are getting at, namely that we are not able to reach an infinitieth term, since however long we continue the progression, the terms are of finite magnitude. But it is not a question of how far we can reach, whether actually or conceptually, but how far has already been reached by nature itself. Yet you concede that all the terms exist at the same time, therefore surely also an infinitieth also exists, and really exists, or is real, for if it weren't it would not exist.

1. By matter per se ôr primary matter ôr bulk, distinct from secondary matter, you say you understand that which is merely passive, and separate from souls ôr forms; but a Cartesian who

has no idea of forms, and who posits the nature of body to be in extension alone, would reply to you here that he does not know what that is which is separate from forms.

2. You say that for you the active without the passive is incomplete, as is the passive without the active; you could have said that primary matter without form is incomplete, as is form without primary matter; but then to a Cartesian acknowledging no distinction between matter and form, the same difficulty would arise as in the preceding.

3. If it is conceded that mass is a congeries of living things or things analogous to them, it could be divided into individual substances; but the Cartesians deny that there is something analogous to the soul in bodies, or they will demand that it be clearly explained what this is that is analogous.

4. If a complete monad ôr individual substance is for you an animal or an analogue to it endowed with a soul ôr form and an organic body, the Cartesians will deny that there is any such monad apart from man.

5. I concede that we do not have to proceed far in order to have substance, not substances, for each and every man is such; but a body they call inanimate, such as a pebble, is to be divided until you have a substance, not substances? For according to you a pebble is not a substance, but substances.

6. I was never afraid that matter, namely secondary matter, is composed of non-quanta, but that it is composed of points endowed with form; since a minimum corpuscle even if infinitely tiny, does not make a substance, but substances; therefore an individual substance needs to be a point with form, not a quantum with form, otherwise it would be divided into many substances.

You see that the whole matter reduces to this, that you should explain the form or analogue to the soul. For I am not a stranger to admitting a third something in body beyond extension and impenetrability, if only I could have an idea of it that is just as clear as the idea I have of extension and and the soul; also I know that a third thing could exist even though I cannot conceive its essence clearly; contrary to the obstinacy of certain Cartesians who hold that what cannot be conceived by us clearly and distinctly does not exist; for they would need first to demonstrate that they can clearly and distinctly conceive whatever exists, otherwise they would conclude no less absurdly than would a blind person who, from the fact that he has never seen the Sun nor could

see it, would wish to argue that it does not exist. This has been objected to them more than once; but the deaf obstinately cling to old refrains, and they perpetually insist on their rule of clear and distinct perception, according to which they judge the thing to be or not to be. In order to please them, therefore, I request that you give a fuller explanation that I could offer them on a given occasion.

But if you would relinquish the term that is objectionable, the *analogue of the soul* or *of the form*, and say that it consists in a certain innate endeavour or originally impressed force, without which body would not be body, but a supposed purely *uniform extension*, as I would thus call it instead of the *prime matter* of the ancients; I believe you would absolve yourself of this business very easily, and more happily accustom the Cartesian mind to unusual terms, as it is immediately made furious by terms it has perhaps only heard used by the ancients. For in this way you could preserve all your dynamics, and explain phenomena of nature such as elasticity, impenetrability, and the conservation of force, etc., equally easily. I do not believe the Cartesians could rightly take exception to such an innate endeavour ôr impressed force, for they are also themselves forced to hold that matter is created together with motion at the same time. Nor, therefore, could they object to its being created even with an infinitely slow motion—that is, with an endeavour towards motion, or with such a force as you very aptly call *dead*—with which you reckon each particle of matter however small is endowed, and indeed I would believe that the various bodies of this world originate according to the different combinations of these endeavours and their directions and tendencies. Certainly I would not dare to deny that the creation of secondary matter consisted precisely in this varied impression of endeavours, but I do not wish to assert that that uniform extension ôr primary matter pre-existed from eternity, and that it was one substance with God, lest I be seen to Spinozise;[15] for it suffices for me to say that it is a concrete extension with that diffusion of forces.

[15] This remark is interesting, because in the decade he spent in Groningen (from 1695 to 1705), Bernoulli was accused of being a Cartesian and Spinozian atheist. Bernoulli mentions his troubles with the theologians in Groningen in his letter to Leibniz of 5 July 1698, A III 7, 810-11. His polemics with the theologian Paulus Hulsius was originated by what Bernoulli had written in his Dissertatio medico-physica de nutritione (Groningen, 1699). See Israel (2001, 436-43),Strazzoni (2019, 175-78). As shown by G. and W. Sierksma, Bernoulli "refuted the accusation by the Groningen theologians that he was denying the 'divine resurrection of the flesh' by maintaining that the body is continually renewing itself, by working out for them that the body contained very tiny threads, which he called stamina, which were unchangeable and which would arise on the 'day of the judgement' covered in earthly matter" ("The Great Leap of the Infinitely Small. Johann Bernoulli: Mathematician and Philosopher", Annals of Science, 56, 1999, 443-49, p. 436). Bernoulli will mention stamina in his attempt to make sense of Leibniz's view on the immortality of living beings, see Bernoulli to Leibniz, 11(21) February 1699, A III 8, 54.

I sent De Volder your postscript straightaway.[16] He will no doubt also have his scruples concerning what you say about forms, so I have counselled him to write to you directly if he wants some advice. What you hold about the law of continuity pleases me a great deal, but when you observe that the speed is not impressed by one impetus, but ascends from rest through all the intermediate degrees, I have been eager to tell you that I have also had such thoughts for many years; but I usually express this in a slightly different way, by saying that Nature neither begins nor ends anything abruptly, in the same way as every principal curve also lacks an end, that is, it either turns back on itself or goes to infinity at both ends, with only some exceptions; hence not only can increasing or decreasing quantities not increase or diminish by a leap, but they also cannot be generated or destroyed by one impetus. And this is more or less one of the main reasons by which I have been induced to conjecture that there are perhaps as many degrees of infinity of a kind exceeding our magnitude, as there are degrees of the infinitely small below us; for I employed this argument in the discussion withVarignon.[17]

Actually, since you do not like the infinite and infinitely small in nature, we will not indeed assume infinities, but incomparables; for just as we have revealed with microscopes little animals incomparably smaller than us and the other animals to which we are accustomed, and undoubtedly if these animals had their own microscopes they would again reveal other animals again incomparably smaller than themselves, and so on: whence, because according to my principle it is not consonant with nature to come to an abrupt halt, I infer (although you may laugh at me) that other animals can exist in nature which are greater than us and the animals to which we are accustomed in the same ratio as the microscopic animals we have revealed are smaller, and which are accustomed to inspect us in our world with a microscope, just as we inspect such innumerable tiny animals; and I also infer that there can be such animals again incomparably greater than them: and thus I propose as many degrees of ascending as of descending, for who would propose limits

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[16] Bernoulli's letter to De Volder is no longer extant, but Leibniz's postscript is attached to his letter to Bernoulli of 20/30 September 1698, cf. A III 7, 911-13. Cf. De Volder's reply to Bernoulli, 21 November 1698, A II 3, N. 190, 476-82(LDV 13-25), where he also replies to Leibniz's PS.

[17] Cf. Bernoulli to Varignon, 24 December 1697, Briefwechsel, N. 31, p. 153: "mais quant à l'infini, tant s'en faut qu'il soit entre deux finis, qu'il y a meme une infinite de degrez d'infinites audessus, dont chacun, quoique infiniment grand, est pourtant infiniment plus petit que le suivant, de meme qu'il y a une infinite de degrez de differentielles dont chacun quoique infiniment petit est pourtant infiniment plus grand que le suivant; effectivement les differens degrez des infiniment grands et des infiniment petits, ne font qu'une suite continue dont chaque terme est la differentielle du precedent et l'integral du suivant, en sorte qu'à l'egard du precedent il est infiniment grand et ä. l'egard du suivant il est infiniment petit".

to divine power? In fact, I do not see (to speak seriously now) why we and our animals should have this prerogative and constitute the highest degree, since, as is patently clear, even such animals incomparably smaller than us could flatter themselves that they and the little drop in which they live could constitute the whole universe, if only they had a rational soul so that they could think.

Concede, or at least imagine, that a little grain of pepper (in which many myriads of living things are discernible by a microscope not only on Leeuwenhoek's testimony but equally from my own personal observation) has parts proportional to the parts of our world as a whole, namely its own Sun, its own fixed stars, planets with satellites, its Earth adorned with mountains, fields, woods, cliffs, rivers, lakes, seas, and various animals. Do you believe that these little peppers, which all these objects regard from the same viewing angle and thus the same magnitude as ours appear to us, cannot believe by the same right that there is nothing outside their grain [of pepper?], by which we ourselves all believe our world to be compounded? For, I ask, what reason and what experience would they have which would persuade them of the contrary, and which would show these miserable creatures that there is another world incomparably greater than their own with inhabitants likewise incomparably greater? For indeed, if these little peppers could not know it, who then among us knows whether the whole of our observable world might perhaps be a only grain with respect to another incomparably greater? For the reason is the same in both cases.

(k) From Leibniz to Johann Bernoulli, 18/28 November 1698: (A III 7, N. 244, p. 943–5).

You say that these metaphysical expressions of mine are too laconic, although if I am not mistaken I gave the means for speaking accurately and elegantly. But if you have remaining doubts, I will endeavour to satisfy them by responding. You say that I had given definitions rather than explanations. But I wish definitions would always be provided, for explanations are virtually contained in them. As far as infinitieth terms are concerned, it seems to me not only that they cannot be reached by us, but also that they do not exist in nature, that is, they are not possible, otherwise I admit, as I already said, if I conceded that it is possible for them to exist, I would concede them to exist. Therefore it must be seen by what reasoning it could be demonstrated that it is possible (for example) for there to exist a straight line that is infinite and yet bounded at both ends. But I come to your numbered points.

On 1.) When I said that *primary matter* is that which is merely passive and separate from souls ôr forms, I said the same thing twice: that is, it is exactly as if I had said that it is merely passive and separate from all activity. For forms are for me nothing other than activities ôr entelechies, and substantial forms are primitive entelechies .

On 2.) I preferred to say that the active without the passive is incomplete, as is the passive without the active, rather than matter without form and vice versa; that is, so as to propose the thing that is explained rather than the thing that is to be explained; and so as to make use of your advice before you gave it, since the common man among the moderns is less offended by the term 'activities' than 'forms'.

On 3.) We should not be deterred by Cartesians who believe that that there is nothing in bodies analogous to the soul, since they have no reasons for their denial; nor does it follow that what we cannot *imagine* does not exist.

On 4.) It has long seemed ridiculous to me that the nature of things would be so poor or stingy that in this globe or ours it would make provision for souls only for such a small mass as the human body, when there could be no obstacle to their being destined for everything else.

On 5.) How far one must divide a pebble to arrive at organic bodies and thus monads I do not know, but you will easily acknowledge that our ignorance in these things does not prejudice nature.

On 6.) I believe that there is no least animal or living thing, none without an organic body, none whose body is not again divided into further substances. Therefore one will never arrive at living points ôr ones endowed with forms.

If you have a clear idea of the soul, you will also have one of form: for it is a variant species of the same genus.

You do very well to conclude that what we do not perceive clearly and distinctly, we must not therefore reject.

Whatever the good Cartesians boast about their clear and distinct perception, it seems to me that they do not perceive even extension in this way.

Besides, if we conceive the soul ôr form as the primary activity from which secondary forces arise by modification, just as figures arise by modification of extension, I think in this way we consult the intellect sufficiently. That is to say, there can be no active modifications of that whose essence is merely passive, since modifications limit more than they increase and add. And so besides extension, which is the seat or principle of figures, we must posit a seat or first principle of actions, namely the soul, form, life, first entelechy, call it what you like.

I entirely approve of your advice that with the Cartesians or their ilk we should abstain from mentioning primary matter and substantial form, and be content to mention mass that is active per se, and entelechy ôr primitive activity, soul, life.

You also do very well to declare that all the bodies in the world originate from the combination of innate forces, and I do not doubt that the forces are coeval with matter itself, since I judge that matter itself could not subsist without forces. I think, however, that primitive entelechies ôr lives are something different from dead forces, which themselves perhaps always arise from live forces; as is clear, since the endeavour of receding from the centre, which should be counted among the dead forces, arises from the live force of circulation.

But life or entelechy is something more than some simple dead endeavour, for I believe that there is in it also perception and appetition, as in an animal, with both corresponding to the present state of the organs.

Plainly, in agreement with my opinion, you are saying that changes cannot happen by a leap. Besides, I am not joking but freely profess there to be animals in the world as much bigger than ours as ours are bigger than microscopic animals. And it can happen in turn, indeed it must happen, that in the least atom-like specks of powder there are worlds not inferior to ours in their beauty and variety; nor can anyone prevent it from being seen a greater wonder that animals are transferred into such worlds by dying, for I believe that death is nothing other than a contraction of the animal.[18]

[18] The last point will raise the curiosity of Bernoulli, who, in his letter of 6/16 December 1698, will interpret this contraction of the animal in terms of Pythagorean metempsychosis (A III 7, 958). After Leibniz replies that he accepts only the metamorphosis of the same animal (A III 7, 967) and that there is no migration of an entelechy from matter to matter (A III 8, 39), in his letter of 11(21) February 1699, Bernoulli formulates a theory based on Leibniz's theory of the indestructibility of the animal, see A III 8, 54-55. In particular, Bernoulli derives the possibility that the same animal could die and be reborn several times (if death is just interpreted as reduction to a smaller scale). Leibniz does not commit himself on this point, he only says: "Idem animal saepius prodire in hoc theatrum

possibile est. Sed tamen et contrarium possibile est" (A III 8, 66). On this topic and the image of the theatre, see Text 7.