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Physics and *Organic Physics*: from States of Matter to Life on Earth (= *Hegel's Philosophy of Nature*. Chapter 3)

The text below was originally written as part of a short book on Hegel's philosophy of nature. Due to rigid external constraints the version of the book published by Cambridge University Press only comprises two chapters, one on Hegel's conception of nature in general, the other on his account of space, time, matter and motion in *Mechanics*. This makes the version published by CUP a fragmented, rather than a comprehensive treatment of Hegel's philosophy of nature.
The present text deals with the remaining parts of Hegel's encyclopedic philosophy of nature, i.e. his philosophical account of kinds and states of matter in *Physics* as well his conception of terrestrial planets, plant life and animal life in *Organic Physics*.

While *Mechanics* deals with the concept of matter *in general* and the motions it gives rise to just insofar as it is heavy, the topic of *Physics* is "qualified matter"[1], i. e. *specific* states or *kinds* of matter and their *characteristic* interactions. *Physics* accordingly envisages *chunks* of matter *as such*, notably their inner structure, rather than treating them as homogenous or as mass points. It thus deals with *species* of matter and specific processes and interactions corresponding to them, rather than with unspecific processes and interactions pertaining to matter in virtue of its general nature.
It might seem that matter in general, i. e. heavy matter, enables the existence of specific states or kinds of matter[2], while being independent of these. In this case, the differences characteristic of specific kinds of matter would be *external* to what matter as such is. *Physics* would thus deal with *additional* features of matter beyond gravity, and it would thus address a completely new topic. Contrary to this assumption, matter in general is an abstraction. The gravitational motion belonging to matter in general *presupposes* that matter comes in specifically different kinds or states. The reason for this is that the *idealized* study of gravitational motion in *Mechanics* presupposes that motion is *real*, i. e. that there are *chunks* of matter that move[3]. There can be such chunks only, if the way in which matter coheres isn't *exactly the same everywhere*. If an *absolute* void is impossible, this condition can only be met, if matter is distributed *inhomogenously* across space, coming in bits with a determinate structure or inner articulation which sets them apart from surrounding matter and allows them to move. If matter comes in bits with a determinate structure, this allows for bits of matter which specifically differ with regard to their structure. *Physics*, accordingly, doesn't deal with *another* subject matter than the motions of matter in general dealt with in *Mechanics*, but it envisages that very same topic from another angle, namely with regard to *specific* states or *kinds* of matter on account of which motion of matter is possible in the first place[4].

[1] $20{,}275^{20}$. References to Hegel's works are given by recourse to volume number, page number, and line numbers of *Gesammelte Werke*, the only critical and complete edition available. Acronyms are explained in the section "Abbreviations" at the end of this Element. All English translations are my own. English editions of Hegel's works are referenced in the bibliography.
[2] Cf. Winfield 2017, chapter 7.
[3] See $20{,}256^{10\text{-}14}$.
[4] One might wonder why self-gravitation, i. e. gravity insofar as it acts within a heavenly body and holds it together, doesn't suffice to explain the existence of movable chunks of matter. *If* matter is inhomogeneously distributed accross space, gravity might very well account for the existence of such chunks. *Universal* gravitation, however, doesn't ultimately account for matter being *inhomogenously* distributed in the first place.

Mechanics envisages *global* or *ubiquitous* features of nature, i. e. space and time as well as motion and matter. *Physics* treats of specific *kinds* and states of matter and might thus seem to be engaged with something that isn't tied to a determinate spatial location. After all, *kinds* of matter can be characterized independently of recourse to determinate places or regions. It might thus seem that matter of various kinds can be *arbitrarily* distributed across the spatio-temporal universe. However, according to Hegel, specific states or kinds of matter are essentially tied to specific regions of the universe, paradigmatically, to certain kinds of heavenly body[5]. That Hegel even asks for the characteristic regions of specific kinds of matter reflects the overall task of his philosophy of nature, namely to envisage nature as a *real* unity. On its own, a *kind of matter* is an abstraction that lacks real existence. This is why envisaging kinds of matter from the vantage point of *Physics* requires one to ask for their respective places in nature.

Are there any non-empirical reasons for assuming that different states or kinds of matter might be tied to different kinds of heavenly body? Obviously, *different kinds* of matter cannot have their ground in the nature of matter *in general*, i. e. gravity. They must rather be based on further 'fundamental forces' or 'interactions' beyond gravity. However, given that nature is a real unity, universal gravitation, on the one hand, and the forces accounting for specific kinds of matter, on the other, cannot be completely independent of one another. In consequence, the local variation of gravity accross the solar system must have a bearing on the interactions that account for there being specific kinds of matter. These interactions will thus yield different results with regard to different kinds of heavenly body. A straightforward example of this is that the state of matter on the central body of a solar system, due to its being the center of mass, will characteristically differ from the states of matter that can be found on peripheral bodies[6].

3.1 On the Significance of Transitions in Hegel's *Physics*

Given that the *philosophy of nature* envisages nature as a real unity, Hegel's conceptual account of specific states, kinds and processes of matter developed in *Physics* and *Organic Physics* involves recourse to specific regions of the physical universe rather than exhibiting those states, kinds, and processes as if they were located in a sort of void or could occur just anywhere.

It would be a mistake to immediately identify the conceptual order of philosophical thought with the real order of nature. In the philosophy of nature *transitions* between concepts must indicate *real* connections between states and processes of matter designated by these very concepts. What kinds of real connection these are will vary with the concepts at hand. The connections *can* be *mutually* necessary, as for instance those between kinds of heavenly body and states of matter envisaged at the beginning of *Physics*. Other sequence of concepts might exhibit preceding states and processes of matter as necessary conditions of those envisaged at a later stage. The circulation of gaseous, liquid and solid matter in a planetary setting under the impact of solar radiation is for instance exhibited as a condition of the occurrence of chemical reactions[7], while chemical reactions in turn are exhibited as a condition of organic life[8]. Given that all transitions in Hegel's philosophy of neature must bear a real significance, his conception of a certain natural kind, e. g. animal life, cannot be taken out of context and envisaged independently. Doing so will inevitably result in a distorted

[5] Cf. 20,277[5-8];283[12-18];285[4-7];TW9,128A.
[6] Cf. 24.1,298[20]-299[5];TW9,114A.
[7] See 24.1,321[24-25];TW9,135A.
[8] See 20,345[8-18];289[16-21];24.1,333[7-8].

understanding of the natural kind in question, namely one that abstracts from its place in nature and further real conditions of its existence. It might thus seem, for instance, that organic life as exhibited in *Organic Physics* could occur just anywhere universe, rather than presupposing a planetary setting and all the states and processes of matter envisaged beforehand.

The real significance of conceptual transitions in *Physics* and *Organic Physics* cannot exhaust itself in that preceding steps bring into view *necessary* conditions of features of nature that are envisaged in later steps. In this case, the series might have lacked real instantiation after a certain point, e. g. that a material universe might as well not involve life. If subsequent concepts such as the concept of life have a real counterpart, indeed, this would thus be a contingent fact, only. Even while resonating with contemporary assumptions, the view that the spatio-temporal universe might as well not have involved organic life and, ultimately, embodied mind, is incompatible with Hegel's understanding of the relation between nature and spirit[9].

Ontological readers of Hegel's *Logic* might be inclined to justify the view that nature *must* involve organic life by recourse to the logical "idea of life"[10]. Independently of whether Hegel's *Logic* provides an argument to that conclusion, such an argument would be insufficient with regard to the question of the sufficient ground of organic life. The logical idea lacks independent existence, and for this reason organic life must have its sufficient ground in nature rather than something prior to it. On Hegel's account, matter must thus be the sufficient ground of the eventual existence of organic life. However, relatively unorganized states of matter as dealt with in *Physics* cannot be straightforwardly understood as necessary *and sufficient* conditions of the existence of more organized kinds of matter and, ultimately, of organic life. At least, they cannot be thus understood, since less organized kinds of matter such as chemical substances and their reactions do not *without further ado* necessitate the existence of more organized kinds of matter such as living organisms.

To bring out the real bearing of the sequence of concepts laid out in *Physics*, Hegel takes recourse to the notion of "real possibility"[11]: the meteorological process and further geological cycles of matter in a planetary setting are said to provide for the "real possibility" of organic life. Generally speaking, a real possibility is something more than a necessary but less than a sufficient condition, if the latter is understood as a condition whose obtaining actualizes the conditioned *without further ado*. That certain material conditions provide for the real possibility of something means that nothing material over and above these conditions apart from their coming together in the right way is needed for that possibility to be actualized, which might very well be a matter of mere chance. Apple juice and sparkling water provide for the real possibility of apple spritzer, because what is required for that possibility to be actualized is just these two coming together in the right way.

By contrast, a stage of the physical organization of matter, as envisaged in Hegel's *Physics*, must do more than provide for a certain real possibility in the ordinary sense of the term. For a real possibility of that sort might as well not be actualized nor does the concept of something that provides for real possibilities whose actualization is *contingent* stand in an *internal*, i. e. *necessary* relation to the concept of a *uniquely* determined real possibility. The real significance of a certain kind of organization of matter as dealt with in Hegel's *Physics* is that it provides for the real possibility of another kind of organization of matter that is *necessarily* actualized *at some point or other* and whose concept is implicit in and uniquely determined by the preceding

[9] See 20,381[24-25].
[10] 12,179[1]-191[31].
[11] 20,347[7-9];24.2,915[33-34].

concept. One might call this sort of real possibility *infinite*, since its actualization isn't dependent on mere happenstance.
Read in terms of infinite real possibility, a certain kind of organization of matter dealt with in Hegel's *Philosophy of Nature* is such that we can know a priori that it provides for the possibility of a further kind of organization which is neither instantaneously actualized nor such that it might never be actualized but is necessarily actualized *at some time or other*. While we can know a priori that a real possibility of this sort must be actualized *eventually*, when and where exactly it is actualized can only be known empirically.
One might wonder, thought, whether the conception of a real possibility that *must* eventually be actualized for a reason that can be known independently of experience might not be fictitious. In order to at least prepare some ground for a response to this question, while not attempting to answer it conclusively, we have to look at Hegel's distinction between finite and infinite processes in nature[12]. A finite natural process actualizes a real possibility by way of *independent* material conditions coming together in a felicitous way, namely one that is sufficient for the actualization of that possibility. That the process in question has *independent* material conditions means that their coming together in the right way is, ultimately, a matter of chance, i. e. that it might as well not happen. The collision of two billiard balls or the chemical reaction between two compounds, for instance, are finite natural processes insofar as their coming together in the right way isn't a consequence of the nature of the material objects involved, but results from motions accidental to them.
An infinite process, on the other hand, is a consequence of the nature of its material conditions alone and thus amounts to the necessary, albeit indirect actualization of a possibility that must eventually be actualized. Hegel conceives of the motion of heavenly bodies in a solar system as the paradigm of an infinite process: the existence of solar systems is a consequence of matter's being essentially both *inert* and *heavy*. Moving forces are not just externally impressed on chunks of matter, but such chunks have both a tendency to keep their own state of motion or rest, *and* a tendency to set themselves in motion towards other matter, while it depends on scale which tendency prevails. Actualization of matter's tendency to move towards and unite with other matter will increase the inertia of the resulting bulk of matter and the accretion process will accordingly result in a distribution of matter in which both tendencies are balanced, namely a system of bodies whose motions are *internally* determined by the bodies involved in it rather than from without. This means that these bodies move in a way that exhibits both their striving towards others as well as their own independence, orbiting around their center of gravity. That matter *as such* takes the shape of solar systems isn't a universal but a categorical judgment, i. e. even while matter can exist in other spatial configurations than those found in a solar system, given the dual nature of matter it is not by chance that there are solar systems indeed. The cyclical motions of heavenly bodies within a solar system thus actualize a real possibility which is grounded in the nature of matter and which can neither be actualized instantaneously nor remain unactualized forever, but is such that it must *eventually* be actualized. Against the background of the characteristic motions within a solar system, the actualization of further real possibilities which appear to be wholly contingent at first sight might be recognized as eventually necessary. Apparently finite processes such as the collision of mesoscopic bodies or chemical reactions between substances in a planetary setting could thus be exhibited as *consequences* of the configurations and motions of heavenly bodies whose *eventual* occurrence is likewise a necessary albeit

[12] Cf. 20,257[1-19];287[18]-288[17].

indirect manifestation of the nature of matter. Processes of that sort would be exhibited as necessary rather than contingent if it can be shown that the happy accidents which provide for their actualization aren't *completely* accidental, after all. Given the *varying* but *recurrent* impact of solar radiation on planetary matter, ultimately, it isn't mere chance that chemical reactions of a certain sort occur in a planetary setting that harbours certain kinds of chemical compound, for instance. That the eventual actualization of certain real possibilities is indirectly necessitated by recurrent motions and processes within a solar system which have their ground in the nature of matter presupposes that the recurrence of these motions leads to a convergence of ensuing changes towards certain threshholds whose transgression results in the actualization of corresponding real possibilities. Hegel does not provide us with a sufficient understanding of such cumulative processes, but with a general outline of stages of the organization of matter that build up on each other, thereby hinting to an alternative to the widespread view that the existence of highly organized forms of matter is nothing but a contingent fact about the material universe.

The assumption that the occurrence of highly organized matter in nature is a contingent fact about the material universe rather than a necessary manifestation of the nature of matter might be seen as the result of confusion between material processes as studied in the laboratory and material processes in nature, – a confusion against which Hegel repeatedly warns[13]. Material processes as studied in an experimental setting are finite in that they are artificially initiated. The epistemological advantage of their artificial initiation is that it allows one to study such processes in a regimented manner, isolating certain features of theirs while abstracting from others. However, the artificial initiation comes at a price: processes studied in the laboratory might lack a counterpart in nature insofar as nature does not on its own provide for the material conditions of these processes coming together in the right way. Many kinds of chemical reaction, for instance, that are brought about in the laboratory, never occur in nature. More importantly, certain kinds of material processes, when brought about in the laboratory, might formally differ from their natural counterparts. This is the case when a process is artificially initiated by recourse to something beyond its material conditions, e. g. by adding a catalyst. In nature, on the other hand, the occurrence of the respective process might be the eventual outcome of changes which have their source in nothing but the nature of matter. Hegel not only reminds us that it can lead to confusion to assume without further ado that a natural process such as lightning comes about in the same way as its laboratory counterpart[14]. Mistaking the laboratory for nature will moreover lead to the misguided view that certain kinds of natural process are simply contingent. For while the artificial initiation of a laboratory process requires an enabling factor that is external to its material conditions, the occurrence of the corresponding process in nature might ultimately be a consequence the nature of matter insofar as this nature manifests itself in solar systems and certain physical processes occuring on planets under the impact of solar radiation.

A natural process is 'infinite' in Hegel's technical sense of the term which does not imply that it is everlasting insofar as it does not rely on multiple conditions that are fully independent on one another. Accordingly, an infinite process cannot be explained by recourse to independently identifiable conditions and external relations between these. Even while critical of an alleged subjectivism in Kant's distinction between mechanistic and teleological explanation, Hegel subscribes to it insofar as he conceives of mechanistic explanation as explanation by recourse to independently identifiable

[13] See 24.1,329[11-18];602[11-20];24.2,1087[14-27].
[14] See 24.1,329[24]-330[4];TW9,145A.

conditions and relations between them, while taking teleological explanation to involve the identification and characterization of parts of a whole by recourse to their role within that whole, and, thus, by recourse to their real relations to other kinds of part[15]. A whole of this sort is a system rather than an aggregate.

If there are infinite processes in nature, such processes and the systems they occur in cannot be given a full blown mechanistic explanation. Logically speaking, the explanation that exhibits the existence of solar systems as a necessary consequence of the nature of matter isn't a mechanistic one, for instance, because it doesn't proceed from parts to whole. As we shall see, on Hegel's account there are further processes on the level of *inorganic* nature that defy mechanistic explanation, requiring a teleological account instead. Insofar as nature comprises a series of material systems such that each actualizes a real possibility essential to matter while providing for the real possibility of an even more organized kind of system, Hegel's conception of the physical universe can be said to be teleological. It isn't teleological in the sense that the physical organization of matter is viewed as the outcome of some sort of purposeful action, but in that the processes that manifest the nature of matter necessarily give rise to a series of organized configurations of matter which *objectively* require explanations that take recourse to parts that are identified through their role within the whole. While teleological, Hegel's account of the physical universe isn't evolutionary, since he is concerned with conceptual insight into the necessity of the series of organized stages of matter rather than with its actual temporal order and further contingent properties, leaving these to empirical science.

3.2 Limitations of Hegel's *Physics*

Hegel's *Physics* is limited in ways that need to be briefly adressed before delving into it. It is partly due to these limitations that *Physics* is not only the "most difficult"[16] but the most neglected as well as presumably the most dated part of Hegel's *Philosophy of Nature*[17]. A first limitation consists in Hegel's exclusive adherence to a mescoscopic viewpoint on qualified matter at the expense of a microphysical perspective. The underlying reason for this is his rejection of atomism which he takes to be at odds with both the continuous nature of the spatio-temporal universe as well as with the plenitude of matter, i. e. the impossibility of filled space being interspersed with absolutely empty spaces[18]. In truth, however, the existence of smallest independently movable bits of matter neither contradicts continuity nor plenitude[19]. In any event, reservations about atomism do not justify the exclusion of a microphysical perspective from philosophical physics. On the contrary, the only reason to even reckon with specific kinds of matter is that motion presupposes the existence of bits of matter that can break free from their surroundings and move. Such bits of matter must obviously be held together internally in a way that differs from how they hang together with their surroundings. There must accordingly be a genus of force different from universal gravitation which is at work within movable bits of matter and accounts for the specific ways in which the *internal* coherence of a bit of matter can differ from the way in which it coheres with surrounding matter. This kind of force must act *locally*, and insofar as there isn't any mesoscopic limit to the size of movable bits of matter, it must act on a microscopic scale. According to modern day physics, it is the three 'fundamental forces' or 'interactions' beyond gravity which fulfill this role[20].

[15] Cf. 24.1,332[25]-333[2];24.2,1111[19-26].
[16] 24.1,574[2].
[17] Cf. Findlay 1973; Winfield 2017, ch. 7-11; and Houlgate 2024 for in-depth accounts of Hegel's *Physics*.
[18] See 20,292[23]-293[3].
[19] Cf. Martin 2020a, 264-275.
[20] Cf. Davies 1986.

Leaving unadressed kinds of attraction and repulsion that act locally on a microphysical scale and account for the existence of movable bits of matter of certain kinds that interact specifically with other bits of matter, Hegel can only provide *indirect* characterizations of such kinds and their interactions. He does so by addressing ways in which the specific internal articulation of matter manifests itself mesoscopically in states and shapes taken by bulks of matter, such as the liquid state or the spherical shape of a drop of water, as well as in the specific interactions of these bulks of matter such as their elastic, their light-reflecting or their chemical behaviour. Hegel *Physics* thus provides a *symptomatology* of the forces that underlie the existence of specific kinds of matter, while leaving the forces themselves largely, if not completely unaddressed. It is only way into *Physics* that he touches upon a force that is supposed to account for the existence of specific kinds of matter and their characteristic processes, characterizing it as a local force marked by polarity, i. e. by an internal opposition such that opposite poles attract each other while like poles repel each other[21].

Hegel's neglect of the microphysical forces underlying specific kinds of matter and their interactions cannot be fully excused by the fact that such forces were unknown to the science of his day. As already indicated, leaving the question for the real ground of *movable* chunks of matter unaddressed is a *philosophical* shortcoming rather than one that merely affects the empirical application of the conceptual trajectory sketched out in *Physics*. This shortcoming cannot ultimately be remedied by *adding* bits and pieces of the modern *empirical* understanding of electromagnetic and nuclear forces to that line of thought[22], illuminating as that may be. For this procedure results in a *patchwork* of philosophy of nature and empirical science, only. Even while affecting the philosophical substance of Hegel's *Physics*, his neglect of fundamental forces of matter beyond gravity doesn't invalidate its philosophical merits as a systematic account of the mesoscopic manifestations of microphysical forces that it leaves unadressed.

A second limitation of Hegel's philosophical account of qualified matter consists in its exclusive adoption of a heliocentric viewpoint at the expense of envisaging the physical specification of matter on a larger cosmological scale[23]. Hegel's dismissal of a cosmlogical perspective is ambiguous, oscillating between the diagnosis that there is too little scientific evidence to start with and the claim that nothing beyond solar systems can have an inherent rationality that requires philosophical reflection. On a philosophical level, the assumption that philosophy can only contribute to the understanding of the shapes of matter *within* solar systems is at odds with the goal of philosophy of nature to bring the real unity of nature nature into view. Any contemporary attempt at reviving philosophy of nature would therefore have to engage with the *shape* of the universe *as a spatio-temporal whole* and, hence, with modern cosmology rather than confining itself to a mesoscopic take on matter at the expense of a macroscopic viewpoint.

3.3 Logical Division of *Physics*

Hegel's account of qualified matter is divided into the *Physics of General, Specific and Total Individuality*[24]. Given that *Physics* deals with *specific states* and *kinds* of matter as well as their respective interactions it might be surprising that its subsections are supposed to envisage types of *individuality*. By individuality Hegel understands the nature of a particular that is internally differentiated and related to itself by way of the

[21] Cf. section 3.6 below.
[22] Cf. Winfield 2017 for an approach of that sort.
[23] Cf. 24.1,31[9-22];32[21-26];266[22-27];283[2-4];24.2,1031[26]-1032[12]
[24] See 20,273[10-17].

relations of its parts to one another. The reason that Hegel's account of kinds of matter deals with types of individuality is that a *kind* of matter is an abstraction and thus something ideal rather than real. In nature, kinds of matter exist as particular chunks of matter. That such chunks are made up by specific kinds of matter will be manifest both in their internal structure, in their overall shape as well as in the characteristic ways in which they interact with one another. The transition from *General* through *Specific* to *Total Individuality* delineates successive stages in which bits of matter can be inwardly structured and outwardly shaped by its own internal forces. As already indicated, this sequence provides a conceptual account of a necessary order, rather than the description of a temporal process.

The first section of *Physics* is devoted to the conceptual genesis of the 'general individual'. It envisages the specific material constitution of heavenly bodies and the ensuing motions and interactions of matter on such bodies under the impact of solar radiation. Hegel speaks of a "genesis" of the "general individual"[25], i. e. the planet, because on his account it is only planets on which *all* general kinds of matter, i. e. all *physical* elements, rather than just some can be found. On this account, the planet is the most concrete, all-encompassing heavenly body insofar as it comprises all physical elements and their respective interactions, rather than a mere selection of these[26]. The planet is nonetheless a merely *general* individual, because it is held together and shaped by *universal* attraction, i. e. gravity. The *specific* kinds of matter it comprises exist as stuff that makes up vast regions of the planet, such as the atmo- or the hydrosphere, while also circulating between these. Accordingly, even while the planet involves all kinds of qualified matter, its unity and overall shape do not yet manifest the specific kinds of the matter it consists of but merely the nature of matter in general.

The general individual, i. e. the planet, is both the necessary condition and the real site of specific individuality as dealt with in the second section of *Physics*. In distinction to general individuality that allows for *one* kind of individual, only, namely the planet, specific individuality comes in various forms. It is the mode of being of material particulars that cohere internally in a determinate manner and interact with other bits of matter in a way that manifests their specific internal unity as, for instance, elasticity does. *Specific Individuality* does not yet address the *full-blown* formation of mesoscopic bits of matter in virtue of the specific kind of matter they consist of, i. e. it envisages the unity of a bit of matter on a generic, determinable level, addressing features such as cohesion or elasticity. Other than the physical features dealt with subsequently the ones envisaged in *Specific Individuality* apply to bits of matter independently of whether they are mixtures of different kinds of stuff or made up of one kind of matter, only.

It is only on the level of *Total Individuality* that the full-blown formation of mesoscopic bits of matter in virtue of the specific kind of matter they consist of is addressed. It is here that the inner structure as well as the outward shape of a material particular are exhibited as the expression of its material constitution. *Total Individuality* not only deals with the inner structure as well as the outward shape of a material body insofar as that shape manifest its material constitution rather than resulting from external impact. It also addresses the characteristic interactions of fully formed material particulars with light, i. e. refraction and color, with the elements, i. e. the physical processes that underly taste and smell, as well as with other fully formed particulars, i. e. magnetism, electricity and chemistry.

[25] 24.1,323[21-23];TW9,136Z.
[26] See 20,284[5-8];24.1,33[24-30];TW9,114-115A.

The threefold division of *Physics* thus provides us with a principled typology of the mesoscopic behaviour of material particulars insofar as that behavior manifests the fact that a bit of matter isn't just matter in general, but consists of a specific kind of matter or some such kinds.

3.4 *General Individuality*: From Light to Planetary Matter

The *Physics of General Individuality* is straightforwardly divided into three parts[27]. The first part deals with "free physical bodies"[28], i. e. the heavenly bodies insofar as they are not just viewed as consisting of matter in general but with an eye on their specific material constitution. Accordingly, the same kinds of heavenly body that *Mechanics* envisaged as homogenous or as mass points are now envisaged as *full-blown* material *bodies* involving different *states* of matter. The second part of the section goes on to distinguish four most general kinds of matter, the physical "elements"[29]. While heavenly bodies such as moons and comets contain some elements only, their entirety is only found on planets. The motions and interactions which the four elements undergo in a planetary setting thanks to the impact of solar radiation are the topic of the third section entitled "the process of the elements"[30].

Physics starts with the concept of light. Hegel's treatment of light is part of an investigation into heavenly bodies and kinds of matter insofar as it is tied to the distinction between between dark and light-emitting heavenly bodies and the corresponding states of matter, namely the state of matter found on stars in contrast to the states matter found on dark heavenly bodies, be they comets, moons or planets. It has already been indicated that Hegel proceeds from *heavy* matter to light by contrasting matter that moves on account of having its center outside of itself with something that moves entirely on its own account, having its center in itself[31]. While it has been argued in the previous chapter that the relativity of motion entails the existence of something that can *only* be in motion and thus moves with absolute speed, i. e. light, Hegel's own appeal to light at the beginning of *Physics* lacks sufficient philosophical motivation, because it is based on an external reflection. Even while Hegel simply takes up the determinate concept of light from empirical science[32], rather than deriving it philosophically by showing that heavy matter and light belong to each other, essentially, his account of light is nevertheless revealing[33]:

The concept of matter that has its center in itself allows to recognize various features peculiar to light as a consequence of its nature. Light is material *in the broad sense* of being something that moves. That is does not have its center outside of itself as heavy matter does entails that its motion is *entirely self-determined*[34]*.* Insofar as its motion is self-determined rather than externally conditioned, light can *only* be in motion, i. e. its motion is absolute[35]. Its velocity must therefore be "absolute"[36] as well, i. e. frame-independent. Insofar as it is essentially in motion, light is *neither heavy nor inert*[37], and *in this narrow sense* it is immaterial. It can thus be characterized as "incorporeal, immaterial matter"[38].

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[27] See 20,277[5-9].
[28] 20,277[10].
[29] 20,285[1].
[30] 20,287[9].
[31] See 20,275[16-18];24.1,827[1-27];TW9,119A.
[32] See 20,278[8-11].
[33] Cf. Falkenburg 1993; Winfield 2017, chapter 7.
[34] Cf. 20,277[22];278[6-7].
[35] Cf. 20,576[20-21]
[36] TW9,112A.
[37] Cf. 20,277[21];24.1,578[21-29].
[38] 24.1,578[19-21];TW9,119A;

Readers have remarked that Hegel's conception of light seems strangely narrow in that he does not count as light certain sorts of radiation which even at his time were be grouped under the same generic concept[39], conceiving of light as first and foremost a sort of radiation that has its source in a star. That Hegel ties the concept of light to the concept of a star might seem odd, because light can have many other sources than processes that go on in a star. The apparent oddity is telling, however, insofar as it reveals a crucial difference between the perspectives on nature taken by science and by philosophy of nature as Hegel understands it. Science legitimately isolates a kind of phenomenon such as light to study and conceptualize it. This in turn allows to investigate how the phenomenon at issue relates to others, e. g. how light relates to light-emitting bodies. Philosophy of nature, on the other hand, is fundamentally concerned with nature as an essential unity. It envisages its topics not as empirical phenomena, but insofar as they can be shown to be necessary aspects of nature as a whole. It is with good reason, therefore, that the real place of light in a material universe, its source in the central body of a solar system, is part of Hegel's concept of light[40].

Physics seeks to distinguish specific kinds of qualitatively different matter. Envisaging the relation between light and matter at the beginning of *Physics* allows Hegel to introduce a first distinction between two such kinds, namely luminescent and non-luminescent matter, while not relying on an external principle of division, relating the concept of light to that of a heavenly body which had already been introduced[41].

Even while the programme of developing a principled division of specifically different kinds of matter by way of distiguishing between heavenly bodies that are a source of light and others which aren't, is reasonable, indeed, Hegel's execution of it seems to go astray. For he seeks to explain the difference between luminescent and dark matter *mechanically* by recourse to friction that solar matter undergoes on account of the sun's rotation[42]. An account of *specifically* different kinds of matter, however, cannot be based on *universal* properties of heavy matter. It would rather have to address proximal forces which account for the internal coherence of bulks of matter. While Hegel investigates the right kind of forces, namely electromagnetic ones, at a later stage[43], the only fundamental force he considers at the beginning of *Physics* is gravity. If one takes recourse to universal attraction alone, however, it must remain unclear why the sun should be a source of light, while other heavenly bodies aren't[44]. In places, Hegel admits to simply proceed from the *given* fact that stars emit light, while elsewhere engaging in *mechanical* speculations about friction as the source of the light emitted by stars. As we know today, appeal to nuclear and electromagnetic forces would be necessary to account for why stars shine. However, Hegel's hunch that the *state* of matter found in stars is different from the states of matter found on other heavenly body has been proven correct.

Hegel's account of the free physical bodies involves a closer look on the kinds of motions characteristic of different types of heavenly body. Hegel attributes rotation to the sun as well as to the planets, while denying it to moons and comets[45]. Not only is this assignment empirically faulty, given that moons can rotate as well, but Hegel's whole procedure is a good example of the misguided *abstract* appeal to logic within the philosophy of nature: it is the division of the *logical* concept in general which he

[39] See Falkenburg 1993.
[40] Cf. 24.2,1060[4-6].
[41] Cf. TW9,114A;24.1,580[5];24.2,1059[30].
[42] See TW9,115A;24.1,580[1]-581[10];1000[24-29].
[43] Cf. E§313.
[44] For a modern scientific account of the cause of solar radiation cf. King 2012, 14-48.
[45] See 20,283[1-11];24.1,569[8-27];TW9,115A.

invokes to account for the presence or absence of rotation on the part of various kinds of heavenly bodies[46].

Hegel goes on to distinguish different states of matter tied to *dark* heavenly bodies. His musings on this topic prove to be a mixed bag as well. Not only is the first part of his claim that comets consist of liquid and gaseous matter, while moons are composed of solid matter[47] empirically false. Even more prolematically, the distinction between the solid, the liquid and the gaseous state of matter is just touched upon in passing, while no attempt at developing the respective concepts is undertaken[48]. Hegel's suggestion that the states of matter are tied to specific kinds of heavenly body is a good example of how his treatment of qualified matter is limited to a mesoscopic viewpoint without inquiring into underlying microphysical forces.

However, the fact that Hegel engages with specific states of matter *indirectly* by envisaging how differences between such states manifest themselves macroscopically, doesn't imply that this engagement would be futile. Other than his passing glance at states of aggregation, his conception of the physical elements is in fact highly illuminating. In *Physics* Hegel seeks to revive the ancient doctrine of the four elements which seemed hopelessly outdated already in his times in light of modern chemistry[49]. On his account, however, the lasting insight contained in this doctrine is physical rather than chemical. The doctrine should accordingly not be understood as a primitive attempt at identifying *simple* material substances or *chemical* elements, but as dealing with "physical elements" which are non-elementary from a chemical vantage point[50]. By physical elements Hegel understands the most general kinds of matter that make up vast regions or spheres of a planet such as the hydrosphere or the atmosphere, while also circulating between these spheres. In order to accentuate their tie to a planetary setting one might call them 'geophysical elements'. A geophysical element such as air is macroscopically homogenous insofar as it typically exists in a certain state of matter such as the gaseous state, even while being heterogenous from a chemical vantage point.

Since Hegel cannot *arbitrarily* introduce a principle of division allowing to specify different kinds of matter occuring on dark heavenly bodies, to achieve a principled division he must take resort to a determination that has already been introduced in *Mechanics* and which is such that matter might behave differently with regard to it. The only behavioral property of matter introduced so far is motion and the only motion-inducing feature of matter introduced so-far is gravity. It must thus be fundamentally different ways for matter to move in the gravitational field of a celestial body which allow us to arrive at a logical division of specifically different kinds of matter. A physical element in the sense of a rudimentary kind of matter is accordingly defined by a characteristic relational property, namely it's characteristic way of spreading in the setting of a celestial body. These specific ways will not be reducible to gravitation, but will manifest underlying differences in material constitution and thus amount to *propria* of specific kinds of matter. It is a limitation of this sort of *indirect* division of qualified matter that a distinction between specifically different ways in which matter can spread in the gravitational field of a heavenly body does not itself show that the states of matter

[46] Cf. 20,283[1-11];TW9,113A.
[47] See 20,283[12-18];24.1,591[12-16];TW9,128A.
[48] From a contemporary point of view, a state of matter such as the gaseous, the liquid and the solid state is the characteristic way in which parts of a relatively homogenous bulk of matter relate to each other, namely as either assuming positions which are fixed with regard to one another (i. e. the solid state), or as switching places while still gluing together (i. e. the liquid state), or as moving independently of one another (i. e. the gaseous state).
[49] See 24.1,321[9-17];TW9,135A.
[50] See 20,285[8-11];24.1,321[17]-324[14];TW9,135-126A.

corresponding to these ways are a manifestation of forces that are essential to matter as such.
Elements are thus identified by different ways of spreading in the gravitational field of heavenly bodies, i. e. by their characteristic directional profile as well as by the characteristic regions they tend to assume relative to one other in virtue of their respective ways of spreading. Insofar as elements are tied to specific regions of a celestial body in which they tend to gather relative to one another, the distinction between them is a systemic one[51]. Given that the elements are characterized by their different ways of spreading in the setting of a heavenly body, when left to themselves they will tend to gather in vast homogenous expanses with relatively clear-cut boundaries, rather than interspersing with one another in a mixture.
Matter's distinctive ways of spreading and the ensuing distribution of the elements in different regions of a heavenly body are indeed tied to determinate states of matter, but they also depend on specific weight. An element that has gathered in its characteristic region will thus typically be in a certain state or certain states rather than others. In its own habitat, the atmosphere, air will be typically gaseous, water in turn will typically liquid or solid, and earth will be typically solid. However, since the conditions on a heavenly body change with its position relative to the sun, the elements may as well change states[52], e. g. water can freeze and the earth in the interior of a heavenly body might well be liquid. Accordingly, the elements cannot be identified with states of matter[53].
We can now tackle the task of arriving at a *concrete* understanding of the four elements by means of a logical division of the concept of an element in general that has just been laid out. The task is, in other words, to arrive at a principled classification of ways in which matter can spread in the gravitational field of a planet.
The first way of spreading one can think of – corresponding to abstract universality – is one that is as undetermined by or independent of the gravitational field as can be. The corresponding element will accordingly move in a way that is largely independent of gravity, i. e. it will have a tendency to spread in *all* directions. Its paradigmatic phase will accordingly be gaseous. In virtue of its far-reaching independence of the center of gravity, the characteristic region of this element will be the outermost shell of the planet. What corresponds to the concept of this element on the part of empirical phenomena is, of course, air, and its natural place, the atmosphere.
We can contrast the *abstract independence* of the directional profile of air with matter whose way of spreading is indeed *specifically determined* by heavy matter outside of it. Both the way in which such an element spreads as well as the region it tends to will thus depend on something *other* than that element. Such *other-determination* can itself be twofold, namely indeterminate or determinate. Hegel calls the two *other-determined* elements in question the "elements of opposition" (*Elemente des Gegensatzes*[54]).
An immediate and indeterminate way for an element's being other-determined is given, if the element *can in principle* spread in *all directions*, while depending for the actualization of its capacity to spread on *other* stuff located in its vicinity. The element in question would thus be a *parasitic* one, so to speak. It can only spread by means of invading other stuff, if it does not come in solid chunks but has a fluid nature, while also not leaving the stuff it invades intact, but destroying it instead. Its way of spreading will thus be entirely negative, and it accordingly embodies, amongst the elements, what

[51] Cf. 24.1,321[1-4].
[52] Cf. e. g. 24.1,328[15-17];TW9,141A. with regard to water.
[53] Pace Findlay 1973; Hösle 1988; Winfield, 2017.
[54] 20,286[1].

Hegel calls “negativity”[55]. Its negativity is both other- as well as self-related. For insofar as it can only exist and spread by destruction, its existence consists in its undermining its own conditions of existence[56]. If we ask ourselves what it is that corresponds to this concept on the part of empirical phenomena, fire is a if not the straightforward answer. There is accordingly some motivation for counting fire amongst the elements.

One might object, though, that fire cannot reasonably be counted as an element, because it is not a specific *kind* of matter, but a *process* involving *various* kinds of matter. However, the concept of a physical element is that of matter characterized by a distinctive way of spreading in the gravitational field of a heavenly body. As mentioned, fire is special in that it is the parasitic element that can only spread by way of consuming non-fiery matter. It isn’t a kind of matter that comes with a distinctive way of spreading of its own, but a process which makes matter involved in it spread in a distinctive way. The flame of a candle provides a vivid example of how it does, namely by sucking up combustible stuff. Generally speaking, fire makes matter spread in its own distinctive way, namely by ‘going up in flames’. This suffices to count it as a physical element.

Both elements of opposition are marked by *finitude* insofar as their directional profile is *other-dependent*, but it is only the third element in which this other-dependence is posited as such. This means that the way of spreading characteristic of this element will be unequivocally determined by other – heavy – matter. It must thus be characteristic of this third element to spread in a way that clearly exhibits its dependence on heavy matter beyond it[57]. The dominant direction of this element is thus downwards along a vertical line towards the center of gravity of the heavenly body. Apart from its tendency to move vertically towards that center stuff of that sort will manifest its utter dependence on other matter also by not even staying on top of stuff of the same sort. Its dominant vertical tendency downwards will thus be supplemented by a tendency to spread horizontally[58]. In consequence, this element tends to gather underneath the atmosphere, distributing itself as a thin layer on top of what it cannot penetrate. The paradigmatic phase corresponding to this element’s directional profile is the liquid state, the empirically observable stuff corresponding to the concept of this element is clearly water and its characteristic region is the hydrosphere.

The preceding logical division of the elements started with an *independent* way of spreading and passed through two *other-dependent* ways of spreading. What remains can only be a *self-dependent* way of spreading, which is indeed characteristic of the fourth element. The fourth element is accordingly one whose way of spreading is so massively determined by gravity that it not does not just tend to move *towards* the planet‘s center of gravity, but at the same time constitute that center. Its way of spreading is thus *self-determined* rather than *indeterminate* or *other-determined* insofar as it tends to move towards *its own kind*. The characteristic phase of that element is solid, and its natural place is at the core of the planet. Its empirical counterpart is earth. That the way of spreading characteristic of this element is *self-determined* also explains why the division is now complete and why there can’t be more than four elements.

Hegel insists that the place of the four elements in nature is the planets[59]. Other heavenly bodies such as moons and comets are not sufficiently heavy to retain gaseous and liquid matter. Comets and moons are therefore made of earth and,

[55] 24.1,327[13-14].
[56] See 24.1,165[8-10].
[57] See 24.1,65[24-29].
[58] See 24.1,328[1-6].TW9,141A.
[59] See 24.1,324[8-11];TW9,134A.

possibly, frozen water, only[60]. The planet, on Hegel's account, is thus the only 'concrete' or 'individual' heavenly body insofar as it includes all four rudimentary kinds of matter, air, fire, water and earth[61].
Even while the distinction between the four elements is drawn with an eye on planet Earth, Hegel clearly distinguishes between the concepts of the elements and their empirical instantiation. He can thus grant that, empirically, other kinds of stuff differing from what we know as air, fire, water and earth might play the roles of the four elements on other terrestrial, i. e. earth-like planets[62]. After all, these roles aren't chemically but physically determined.
As we have seen, the elements are characterized by a tendency to gather in certain well delimited regions of their planet such as the atmosphere or the hydrosphere. Such regions are called 'geospheres' in contemporary earth systems science[63]. Geosphere and element are interdependent concepts: each term can be defined by recourse to the other: A geosphere can be understood as a subspace of the earth that tends to be occupied by an element, and an element can be understood as relatively homogenous stuff with an inherent tendency to occupy a certain geosphere.
An element is accordingly relatively homogeneous stuff which *in relation to other kinds of stuff* has the tendency to spread in a specific way and to occupy a characteristic sphere of a planet. However, an element cannot be identified with the stuff located in its characteristic region, because a planet is exposed to the influence of solar radiation which constantly causes a portion of elemental matter to leave its home base[64]. The externally induced motion of elemental matter through alien spheres has the character of a circulation, i.e. such matter ultimatley returns to its original sphere due to its own relative distribution tendency.
An element is thus essentially characterized by its role in the whole, insofar as the division of a terrestrial planet into geospheres is not a static given, but is mediated by the constant return of elemental matter which had been removed from its proper sphere due to the impact of solar radiation. For their part, the geospheres are dynamically determined by their contribution to the organization of the whole insofar as they are, on the one hand, the natural abode of their characteristic element and at the same time a place of passage for other elements with an inherent tendency towards other regions.
A terrestrial planet is accordingly a material system that has the character of a steady state, a dynamic equilibrium: the relatively stable distribution of elements accross geospheres, their permanent externally induced removal from their characteristic sphere notwithstanding, is the result of an interaction between certain parts of the whole. The geospheres as constituted by the elements in their characteristic region exist only due to interactions with each other and the circulation of elements between them. They are thus cause and effect of each other. Water, for instance, is not found in the hydrosphere simply because it is there by nature, but because of atmospheric processes which, upon removal, lead to its return to its proper region by way of of precipitation. The existence of the hydrosphere is accordingly mediated by the atmosphere. For its part, the lithosphere owes its existence to the hydrosphere insofar as earth constantly erodes due to the impact of water and air and dissolves in the hydrosphere, from which it emerges again in the form of newly formed rocks due to a precipitation of sediments.

[60] See TW9,126-127A.
[61] See 24.1,285[4-8].
[62] Cf. 24.1,320[12];24.1,33[16-7];TW9,132A.
[63] Cf. Jacobson 2000, 4.
[64] See 24.1,330[20]-331[6].

It is the entirety of these motions and interactions which Hegel calls “the elemental process” (*elementarischer Prozess*[65]). Its most prominent constituent is the meteorological process which consists in cyclical motions and interactions between water and air. The elemental processes comprises further motions and interactions, involving earth and fire, such as erosion, sedimentation, the formation of rocks, and vulcanism. Passing through further stages of *Physics* such as magnetism, electricity and chemism would allow to enrich the inchoate conception of the elemental process by further features. While we cannot pursue this issue any further, it would not only lead to a more concrete conception of the meteorological process, including lightning and thunder, but it would also allow for a more encompassing understanding of the role of fire in the earth system as a whole.

3.5 From *Specific* to *Total Individuality*

The remaining parts of *Physics* shall now be briefly surveyed. Hegel‘s account of *specific* individuality deals with the most generic – determinable – ways in which chunks of matter cohere internally insofar as these ways are mesoscopically manifest in comparison to or by way of interaction with other chunks of matter. The most immediate and *ideal* way in which differences in the inner constitution of bits of matter can be mesoscopically manifest is ‘specific gravity’ or *density*, i. e. the *ratio* of mass to the volume filled by some kind of matter. *Cohesion* manifests the internal coherence of a bulk of matter in a way that involves *real* contact with further bits of matter rather than mere comparison with them: a further bit of matter can either weigh on a given one, manifesting its *carrying capacity*, or it can allow that bit of matter to manifest its inner coherence by way of *adhesion* to its surface. *Elasticity* in turn manifests inner coherence in a way that involves even more thorough interaction, brought about by shear forces. It manifests the inner coherence of a bulk of matter by the extent to which that bulk returns to its initial shape once it has been pushed or pulled. *Sound* is exhibited as affiliated to elasticity insofar as it is produced when the parts of a chunk of matter upon being struck resume their default states by way of oscillating around it. In sound the inner form of a resonating chunk of matter attains independent existence insofar as sound manifests the specific internal constitution of its source in a surrounding medium. Sound, on this account, isn’t merely a subjective effect, but has a determinate foothold in the material constitution of the sounding object itself[66]. It can neither be located in the medium through which it is transmitted nor be identified with the mere vibrations of the sounding body but rather encompasses both[67]. The fact that objects of equal shape made of different materials can sound differently justifies Hegel‘s treatment of sound as a form of *specific* individuality, while the fact that particular objects made of the same material can sound differently depending on shape indicates that there is a dimension to sound that belongs to *total* individuality. The last form of specific individuality is *heat* which Hegel correctly explains as consisting in communicable motions of the parts of a bulk of matter rather than being a material substance of its own.

Total Individuality deals with material objects *as fully formed*. The form of a material particular is the unity of that particular insofar as it manifests its specific material constitution. Form results from formation: it is the outcome of morphogenetic processes driven by the material constitution of the object at hand. Formation comprises both the inner structuring of a chunk of matter as well as its outward shape insofar as that shape is determined from within rather than by external impact. The first

[65] 20,287[9]-290[9].
[66] See 20,297[15]-300[15].
[67] On Hegel on sound cf. Schambaugh 2023.

section of *Total Individuality* entitled *Shape* deals with fully-formed bits of matter on their own, while the two subsequent sections envisage the interactions of such bits of matter with light (i. e. refraction and color), their interaction with and dissolution in the elements water and air (i. e. the physical basis of taste and smell) as well as their interactions amongst each other (i. e. magnetism, electricity and chemism).

When dealing with shape and the physical processes that yield the inner structure and outward shape of a chunk of matter[68], Hegel comes as close as it gets to philosophically addressing the microphysical forces which account for there being kinds of matter in the first place. According to him, the forces that account for the formation of matter of which the growth of a crystal is the paradigm must be both microscopic and bipolar in nature. Only if tiny bits of matter incorporate some sort of bipolarity that comes with a spatial orientation can the orderly growth of crystals and the regular shape of the mesoscopic result of such growth be understood[69]. Orderly growth and regular shape can thus be recognized as a manifestation of attractive and repulsive forces inhering to tiny bits of matter *in a spatially oriented way* such that these bits tend to arrange themselves in a symmetrical manner[70].

Hegel refers to the bipolar "principle of formation" which underlies the inner structure and overall shape of "all bodies" as "abstract" magnetism[71]. That he conceives of that force on the model of *ordinary* mesoscopic magnetism which, as he rightly insists[72], only pertains to specific materials such as iron or cobalt, makes sense, given that the underlying fundamental forces were not yet known. Ordinary magnetism can be taken as a mesoscopic *model* of the bipolar nature of matter located at the microscopic level in light of the fact that magnets display an *overall* bipolar structure which is reproduced on a smaller scale when they are split up into parts. It is thus reasonable to assume as Hegel does that all matter involves a bipolar structure on the microscopic level, while only specific materials display it on the mesoscopic level.

Hegel's account of the inner structure and outward shape of mesoscopic particulars as reflecting their material constitution is followed by an account of how such objects interact with light as well as with the elements. While a venerable tradition in early modern philosophy had conceived of color, smell and taste as secondary qualities, i. e. as qualities that do not pertain to material objects *as such* but are mere effects of matter onto a perceiver, Hegel's treatment of these qualities indicates that they have an objective dimension nonetheless[73]. Refraction and color are the result of an interaction of light with specifically structured and shaped bits of matter, while the physical processes underlying our experience of taste and smell consist in the dissolution or volatilization of specifically structured and shaped bits of matter in a liquid or a gaseous solvent, typically water or air. Even while it might be difficult to concretely disentangle anthropological and psychological dimensions of taste and smell from their underlying physical dimension, it is a valuable insight that there must be a determinate physical aspect to them indeed: the subjective experience of taste and smell reflects the fact that bits of matter dissolve and evaporate differently in virtue of differing internal structure and corresponding outward shape.

Hegel recognizes that magnetism, electricity and chemistry are all manifestations of the same underlying polar forces[74]. He insist, however, that they are different kinds of

[68] Cf. 20,307[5]-311[4].
[69] Cf. 20,310[29]-311[4].
[70] Cf. 20,309[29]-310[9].
[71] 20,307[11-13];20,308[1-3].
[72] Cf. 20,308[4-6].
[73] On Hegel's account of the physical aspect of color, taste and smell cf. Winfield 2017, chapter 10.
[74] See 20,308[21]-20,309[13].

phenomena, even while one can cause the other[75]. While magnetism is based on a parallel orientation of *parts with polar charge within a body*, electricity consists in an *interaction between two bodies of opposite charge* involving a flow of charged particles that results in neutrality. While electricity doesn't affect the inner structure of the bodies at hand, chemism does. Chemical reactions consist in an interaction of particles with polar charge that results in a reconfiguration of these particles. Such reactions only take place between particles with specific structures which have an affinity for each other[76]. Insofar as these particles have a certain relative stability on their own, a chemical reaction requires some sort of mediator that helps the reactants to reconfigure, while not itself becoming part of the product[77]. The role of the mediator can be cast in various ways, e. g. by heat, by a catalyst or by a medium such as water[78]. Chemism is finite[79]: the reactants must come together in one place, while not having any tendency to do so on their own initiative, since they exist independently of one another; they can only react by the aid of a mediator; and they differ in kind from the products of the reaction. Insofar as chemism is a finite process, it can only occur if suitable conditions are *given*. In the laboratory such conditions are artificially created by way of human intervention. They must be *naturally* provided for, if chemical reactions are to occur *in nature*. Some of the peculiarities of Hegel's treatment of chemistry start to make sense once one understands that he seeks to account for the place of chemism in nature, i. e. to account for the *physical* conditions which allow for chemical reactions to occur.

On Hegel's account chemism is essentially an ongoing planetary process, i. e. steady chemical reactions are tied to a planetary setting rather than occuring just anywhere in the universe. Thanks to the circulation of matter under the impact of sunlight planets provide the conditions for potential reactants to come together in one place. A terrestrial planet is one on which all four elements, air, fire, water, and earth can be found. Insofar as terrestrial planets are multiphase systems, they provide gaseous or liquid media, e. g. water and air, for chemical reactions to occur. That the place of chemistry in nature is the planet is reflected in Hegel's typology of four general kinds of chemical reaction which involve water, air, electricity and fire as mediators[80]. While this typology might seem strange if viewed from the vantage point of contemporary experimental chemistry with its focus on molecular structure and reaction mechanisms it makes much more sense as an attempt to classify kinds of reaction that *naturally* occur in a terrestrial setting.

3.6 Outlook: Life on Earth

A chemical process that reproduces its own conditions, i. e. a self-perpetuating chemical process, would be life, as Hegel explains[81]. However, since chemical process is finite, it does *not* reproduce its own conditions, and for this reason life isn't a chemical process, even while involving such processes. What chemism as a planetary process indeed provides for is the real possibility of life[82]. If viewed *against the background of a terrestrial planet*, it might seem that chemism could indeed be self-sustaining and that life might be a chemical process nonetheless. Why couldn't there be a chain of chemical reactions that produces its own reactants, if that process is kept going by

[75] See 20,309[13]-20,309[27].
[76] Cf. 20,327[14-20].
[77] Cf. 20,328[10-15].
[78] For Hegel's logical conception of chemism cf. Martin 2012, 393-405; for his concrete account of chemistry Winfield 2017, chapter 11.
[79] See 20,329[11-17];342[10-17].
[80] Cf. E§§328-334.
[81] See 24.1,413[13-19];TW9,333A.;20,343[16].
[82] See 20,342[7].

solar radiation and the circulation of matter driven by it? As a matter of fact, Hegel seems to suggest just that, claiming that the types of geochemical reactions he treats of form a "circle"[83].

However, a chemical process that produces its own *reactants* would still be something less than a process that reproduces its own *conditions*, i. e. a self-perpetuating process. For a chemical reaction requires more than just the right kinds of reactants. It moreover requires them to come together *in one place under the right conditions*. A chemical reaction that reproduces its own reactants cannot as such ensure that these come together in one place in the way that allows the same kind of reaction to start anew. A chemical process that reproduces its own conditions therefore requires something more than the mere reproduction of its own reactants, namely a stable boundary that establishes an appropriate site for the reaction and prevents its products from dispersing into its environment. This is why life isn't a kind of chemical reaction, after all. A chemical reaction can only perpetuate itself, if it is tied to a body that provides for an appropriate site of self-perpetuating reactions, enabling their products to actually react anew. Reflecting on the possibility of a self-reproducing chemical reaction we have thus gone beyond chemistry and, indeed, beyond *inorganic* physics. For what we have brought into view is the *general* concept of an organism in the sense of a particular body that provides the appropriate site for chemical reactions that reproduce their own reactants[84].

Insofar as the cycle of geochemical reactions hinted at above is bound to a terrestrial planet that provides for its ongoing occurrence, we have already reached the concept of a first kind of organism which Hegel calls the "geological organism"[85]. It might seem surprising that Hegel conceives of terrestrial planets, such as planet Earth, as a kind of organism. However, given his *general* concept of an organism, it is perfectly consistent to distinguish between organisms that are alive and ones that aren't. An organism in general, as we have seen, is a particular body that provides the appropriate site for the ongoing occurence of chemical reactions that reproduce their own reactants. Insofar as a terrestrial planet provides conditions for recurrent geochemical reactions it can thus count as an organism, albeit one that isn't alive.

What all organisms, living or not, have in common, is that they are bodies involving a form that is being preserved by way of self-reproducing processes. That organisms involve a form that is being preserved in the course of certain changes, follows from their involving self-reproducing chemical processes. Insofar as these processes are *chemical* they involve material changes, and insofar as they are *self-perpetuating* these changes lead to the preservation of a certain kind of unity. However, depending on whether the organism is a geological or a biological one, the kind of unity that is being preserved by way of self-reproducing chemical reactions is fundamentally different, as we shall see in a moment.

The *geological* organism is a kind of planet. As such it does not owe its existence as a particular body to self-reproducing chemical reactions but to the force of gravity. The form that is being preserved in the course of self-perpetuating geochemical processes is therefore just a certain kind of dynamic distribution of kinds of matter in the outer shell of the planet rather than providing for its existence. In contrast, the living organism only exists thanks to the recurrent processes for which it provides the site. The form that is being reproduced in the course of these processes is the characteristic unity of the organism on the whole. A biological organism is thus a material particular that only exists in virtue of contstantly reproducing itself. Its constant self-reproduction is its life.

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[83] 20,329[19-21];TW9,301A.
[84] Cf. 20,343[4-17].
[85] 20,344[11].

It might appear that Hegel's view of terrestrial planets as a kind of organism is a mere oddity. However, the apparent oddity encapsulates an important insight. On Hegel's account, organic life cannot occur in any arbitrary corner of the universe, but on terrestrial planets only. In other words, the geological organism is the real site of biological organisms, the place of life in nature[86]. For it is terrestrial planets that are fertile, on Hegel's account[87], i. e. they provide for the real possibility of organic life[88]. Hegel's concept of the geological organism as the site of life repudiates the widespready philosophical tendency to disavow the terrestrial nature of life. Insofar as the Earth is a particular planet, it is indeed appropriate to not tie the concept of life to it. This, however, should not make one forget that organic life requires a certain kind of place, namely a fertile, life-enabling environment. Hegel's treatment of the geological organism provides the general concept of a life enabling-environment, while also dealing with geological features of planet Earth[89]. As everywhere in Hegel's *Philosophy of Nature* one should clearly distinguish between two tasks, namely the primary task of providing a philosophical concept, in this case that of the geological organism, and the derivative task of matching that concept with empirical phenomena corresponding to it.

Given that organic life is the process by which a material particular constantly reproduces itself and that it requires chemical reactions that reproduce their reactants, there is good reason to assume that organic life can only occur on a terrestrial planet. For life will require a constant influx of energy and a circulation of matter that enable chemical reactions as well as multiple states of matter insofar as the organism needs both solid matter to establish a stable boundary between itself and its environment, as well as a fluid interior that allows for an exchange of matter with its environment and provides the site for life-enabling chemical reactions.

With regard to life, Hegel adopts two Aristotelian insights. Life isn't a property of organisms, but the activity which provides for their unity and, hence, their "being"[90]. In consequence, "life" is "said in many ways"[91], i. e. it doesn't mean the same with regard to vegetative life, animal life, and rational life. Since life is the way of being of the living, the specific differences that distinguish vegetative, animal and rational life cannot be added on top of a life they all share in[92]. These differences rather affect the whole life-process. Vegetative life isn't fully individual but 'dividual', since the growth of the plant *consists in* producing potential offshoots, i. e. parts that can exist on their own[93]. Animals or sentient organisms, on the other hand, are individuals indeed, since they are essentially *presented with themselves* by way of perception and feeling[94]. In consequence, they do not nourish and reproduce in the way plants do, but in a way that is informed by their sentient nature and thus consists in *self*-motion that is oriented by perception and driven by feeling[95]. Spirit or rational life, in turn, is life that isn't *partly* animalistic and *partly* informed by reason[96], but a life that is on the whole permeated

[86] See 20,345[8-18].
[87] See 20,347[2-23].
[88] Cf. Martin 2025a for a reconstruction of Hegel's conception of the geological organism as a precondition of the biological organism; Martin 2025d on the idea that the circulation of matter on a terrestrial planet is a necessary condition of life; and Martin 2024 for Hegel's view of the Earth as the natural habitat of spirit.
[89] Cf. Lyssy 2024 for a study of Hegel's conception of the geological organism that covers both strands.
[90] Aristotle, *On the Soul*, 415b13. Cf. 23.2,797[35-36].
[91] Aristotle, *On the Soul*, 413ab22-25.
[92] Aristotle, *On the Soul*, 414b20-415a11. Cf. TW19,203-205;30.1,315[13-24];30.2,610[23-32]. On Hegel's appropriation of Aristotle's conception of life cf. Martin 2011.
[93] 20,348[4-19].
[94] 20,352[13-18].
[95] A reconstruction of Hegel's conception of plant and animal life in a terrestrial context that is both historically and scientifically informed as well as systematically ambitious can be found in Winfield 2018.
[96] Cf. Boyle 2012.

by thought[97]. In consequence, even the apparently 'natural' aspects of human existence transcend the proper field of philosophy of nature. So there is good reason that Hegel deals with them separately, in the first part of his *Philosophy of Spirit*, namely *Anthropology*. Mindedness or spirit, on Hegel's account, isn't part of nature, even while being enrooted in nature: spirit is the "return" of self-determination under natural circumstances which transforms and transcends these circumstances[98]. In consequence, the philosophical self-knowledge of spirit requires knowledge of nature, indeed, – not because spirit would be something natural, but because it is nothing but the transcendence of nature that proceeds from amidst nature.

[97] See 21,10[24]-11[4]. Cf. Haase 2013 on the relation of life and mind in Hegel and Stein 2024 on the non-physicalist, non-naturalist and anti-essentialist character of Hegel's conception of nature and spirit.
[98] See 20,381[24]-382[3].

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