Individuation and scientific thinking: Simondon's philosophy of transduction

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A thesis submitted in partial fulfilment of the requirements of Kingston University for the degree of Doctor of Philosophy.

Faculty of Arts, Kingston University.

March 2021.

Contents

Acknowledgments

I would like to thank Graeme Kirkpatrick, Cristina Masters and Paul Simpson, whose inspirational teaching at Manchester University motivated me to pursue further academic study; without their encouragement, this thesis would likely not have been written. I am enormously grateful to both staff and students at CRMEP for working so hard to create and maintain a fertile environment for thinking. This thesis has benefitted immensely from the extraordinary master's and doctoral programmes which I took at CRMEP. I am also very grateful for insightful comments and questions from staff and students at CRMEP during developmental stages of this thesis. In particular, I am thankful for engaging discussions with Eric Alliez about Deleuze, Foucault and Simondon, and for Peter Hallward's close and critical readings of early drafts. Thanks are also due to students at Paris VIII, respondents at events held at SEP-FEP, Kings College London and Royal Holloway, and to Giovanni Menegalle, for his general encouragement and thoughtful comments on the second chapter of this thesis. Enormous thanks are due to Howard Caygill, who has been a consistent source of inspiration, orientation and reassurance throughout my time at CRMEP. Howard's rare gift for insight and generosity has been greatly appreciated.

Whilst preparing this thesis I have also had the great fortune of good friends and family. Thanks are due to all those who have lived with me at 1c over the years, who have been a source of both stimulation and respite. Special thanks go to Melisa, who helped me through the travails of thinking and writing with indefatigable kindness and understanding. Thanks also to my sister, Emily, for putting me up in Paris so many times and for many years of love and support. Finally, thanks are due to my parents, Julia and Nick, for their love, care and encouragement which, seemingly endless, were in particularly great supply during these difficult years.

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Abstract

This thesis explores the ways in which Simondon's transductive ontology both engages with and is made possible by natural scientific thinking. It is argued that Simondon's conception of transduction signals the necessity for an engagement between ontology and contemporary science and makes a number of significant contributions to this task - in particular, regarding his conceptions of energy and relation. In part, we attempt to demonstrate and defend his philosophy of transduction as a fruitful engagement with natural science, whilst equally it is argued that a number of aspects of this relationship are problematic.

The general and guiding problem of this thesis is the possibility of an ontology in light of contemporary scientific thinking and discovery. Simondon's conception of transductive individuation is a significant attempt in this regard, as it rethinks ontology and individuation in light of theories, concepts and descriptions derived from contemporary science. This thesis attempts to situate Simondon's ontology relative to direct influences on his work and texts from the scientific and philosophical context in which he was writing. Close attention is paid to his engagements with the science of energy, concepts of relation in twentieth-century biology, epistemology and ontology, and cybernetic articulations of homeostasis and information. In this way, we equally contend that scientific thinking is not of mere conceptual inspiration for transduction, but instead offers ontological descriptions on which Simondon's ontology rests.

As the argument progresses, problematic or unthought aspects of the relationship between transduction and scientific thinking are emphasised. Discussing Simondon's thought in light of that of Bergson and Deleuze, we emphasise and problematise the differences between their expressions of singularity and their relationships to scientific thinking. The primary problem, in this regard, has to do with the priority and nature of scientific thinking: if thought comes first, constituting and confirming Simondon's transductive philosophy and Deleuze's ontology of difference, then it may also constrain individuation or creativity to scientific concepts. Equally, if scientific thought is developing through a process of error and rectification, then it may not be the stable foundation articulated and required by ontologies such as those of Simondon and Deleuze.

Introduction

It is sometimes said of Simondon's work that it was underappreciated during his lifetime and that it remains so today; in short, that careful textual engagement is long overdue. This is correct to a certain extent, but it underestimates the engagement Simondon's work enjoyed during his lifetime, including favourable discussions by Gilles Deleuze, both with and without Felix Guattari, but also less widely recognised reflections in texts by Jean Baudrillard, Herbert Marcuse and Pierre Naville. Many of Simondon's contemporaries have also attested in conversation that *Du mode d'existence des objets techniques* was very widely read after its initial publication in 1958.

Simondon's work never went unread, but he may have been deserving of Jean-Hugues Barthélémy's appellation "plus connu des inconnus", nonetheless.[1] This may mean, ultimately, that his name was very well known, his work widely read and sometimes cited, but that it did not have monographs, special issues of journals and colloquia dedicated to it. This situation has changed in the last twenty years, during which there has been an intensification of engagement with Simondon's work. Discussion of his texts has shifted from wide readership but primarily brief or passing comments, to a number of book-length studies, multiple special issues of journals, a number of conferences and numerous chapters and articles. Today Simondon's work enjoys considerable renown, even if he is a more minor figure than the "great thinkers" of French philosophy.

It is worth acknowledging the sixty-two years between the completion of Simondon's work and this thesis. His engagement with technics and science are often described as more-or-less untimely, prescient then and consequential now.[2] To an extent this is true, and this thesis emphasises the fact that Simondon's texts are amongst the few to recognise the philosophical implications of broad conceptual shifts in the natural sciences and technics which still have purchase today. In this sense, Simondon remains atypical in his recognition of the significance for philosophy of energy, information and cybernetics.

[1] Guchet, X. (2010), 2.
[2] See, for example, Mills, S. (2016), 1.

However, it must also be acknowledged that in many respects, Simondon's work was profoundly timely. The term "cybernetics" was only two years old when Simondon wrote his two theses, and the "discipline" in its very early stages. Equally, it almost need not be stated that the nature of technical objects has undergone enormous transformation since the publication of *Du mode d'existence des objets techniques* (henceforth, *Du mode*). Indeed, whilst vacuum tubes, Simondon's paradigm examples of technical concretisation, were numerous and very significant technical objects in the late fifties, today they are almost non-existent, having been largely superseded by transistors (today as small as a single atom). His philosophy of individuation equally appears, in some respects at least, outmoded today. *L'individuation à la lumière des notions de forme et d'information* (henceforth *L'individuation*) almost completely ignores evolution by natural selection and underestimates the significance of the Copenhagen interpretation of quantum mechanics (surely impossible today), whilst it was written before the recognition of the significance of non-linear thermodynamics.

Ultimately, this may point towards a fault on the part of philosophy, when it comes to recognition of contemporary scientific and cybernetic developments. While Simondon's philosophy recognised and reflected on the nature of the period in which it was written, much of the rest of philosophy may be only just arriving on the scene. In this thesis we attempt to address something of this tension between prescience and contemporaneity of Simondon's work; what remains relevant for philosophy and what is of historical interest.

Simondon's most significant work was produced early in his life and submitted as two doctoral theses (in 1958). His *thèse principale* - *L'individuation* - was written on the problem of individuation and his *thèse secondaire* - *Du mode* - on technics, the genesis and ontology of technical objects. The latter was published in 1958, whilst *L'individuation* was first published in 1964, though appearing only in abbreviated form, including the first two parts (on physical and vital individuation) but omitting the third. The final part of *L'individuation*, on psychic and collective individuation, was eventually published in 1989, though in a stand-alone text which omitted the first two parts. It was not until 2005, then, that *L'individuation* was published as a whole, including all three parts.

Accepting that his two theses constitute his most significant work, more recent literature has demonstrated an interest in reading both texts together in order to grasp Simondon's philosophy as a whole. Generally, there is an assumption that the two texts should be read together, as a progression from a natural ontology which leads to technics. Almost all of the monographs written on Simondon's work are thus structured according to a logic which would treat *L'individuation* as a first philosophy and technics (hence *Du mode*) as in some sense secondary.[3]

If the two theses do form a whole project, Simondon is unforthcoming as to the way in which the two texts fit together, and this reticence has provoked a certain puzzlement on the part of some of his readers. Xavier Guchet thus argues that one cannot avoid "perplexity before the difficulty in seeing at first what provides the unity of these two sorts of research to which this puzzling philosopher has dedicated himself".[4] Jean-Hugues Barthélémy is more confident that the two texts are unified, but proposes that there is some mystery concerning what unites them: "the theme of the living being contains the hidden unity of Simondon's work, even beyond that first surface unity presented by the transversal theme of individuation".[5]

There is no doubt that there are thematic, problematic and conceptual similarities between Simondon's two theses (and indeed other texts), such as genesis, individuation, relation, energy and information. But overlapping themes do not provide unity of the kind that these readers seek. Barthélémy does not want "surface unity" but argues that he finds a "transition" between the two texts, Bardin contends that there is an "articulated interconnection between his philosophy of science and technology and his political philosophy", and Mills proposes that Simondon's "axiomatic theory of ontogenesis…is able to produce a coherent philosophical project that includes an ethics, epistemology, aesthetics and technical philosophy".[6] For his part, Guchet is shocked that at a presentation in 1960 (two years after submission of his theses), Simondon does not explain how his two theses fit together, or "attempt to give a vision of the whole of his

[3] See, Bardin, A. (2015), Barthélémy, J.H. (2008), Hottois, G. (1992), Mills, S. (2016), Combes, M. (2012). Of the texts which would grasp Simondon's thinking as a whole Chabot's (2003) is the only one which bucks the trend, with part one on technics, part two on individuation and part three on the "bridges" between the two.
[4] Guchet, X. (2010), 1.
[5] Barthélémy, J.H. (2015), 19.
[6] Ibid. (2008), 17; (2008), 115; Bardin, A. (2015), 1; Mills, S. (2015), 4.

work, of the general intention which animates it, and give a clear response to the question of the unity of his works."[7]

When Simondon was asked (in 1968) about the connection between his two texts, his answer, it seems, did not satisfy his readers. Interviewing Simondon for Canadian television, Jean Le Moyne begins by explaining that *Du Mode* has had a great impact on its readers, but that

> our admiration is mixed with a certain astonishment. We frequently ask ourselves how thought so firmly centred as yours on the problem of individuation arrived at mechanology, to study the technical object as such?[8]

Le Moyne is thus surprised, like Barthélémy and Guchet, at the apparent disunity of the two theses, between individuation and the study of technical objects.

Simondon replies: "I understand… actually, I don't know how to put it, there are always academic contingencies [*des hasards universitaires*]."[9] He then attempts to offer Le Moyne a more satisfying answer, but only discusses his position in *Du mode*, and says nothing of the connection between the two texts.[10] It is worth remembering that these "academic contingencies" were fairly significant. Doctoral examination in France during Simondon's years of study required that a student write two theses, both of significant length. One response to Guchet's question regarding the "general intention which animates" Simondon's two theses is simply the fulfilment of the institutional demands on a doctoral student in 1958 in France: to write two original texts of sufficient length on two different topics.

If the living being provides the link between the two theses, as Barthélémy contends, it remained hidden even to Simondon himself, and if there were a general animating intention whilst writing the two doctoral theses, it seems that by 1968 Simondon had moved on. Equally, if there had been a unified project, as Guchet suggests, Simondon

[7] Guchet, X. (2010), 4.
[8] Simondon, G. (2014), 407.
[9] Ibid., 407. Ellipsis original.
[10] He continues: "However, it seems to me that a real relation exists", but he does not respond to Le Moyne's question, explaining the unity between individuation and mechanology. Instead, he goes on to explain that a technical object is a unity relative to the world, that it is "a unity, a solid unity, an intermediary between world and man, an intermediary perhaps between two other technical objects", but says nothing of the connection between the two texts.

had ample opportunity to explain the connection between his two theses or indeed to produce such a unified work.

Although many readers approach *L'individuation* and *Du mode* as if they form a single continuous project, none arrive at a conclusion more convincing than the fact that technics results from a living being which would first have an individuation. There is no necessary connection between the two works, nor does Simondon explain the link where he might - in the section on psychic individuation or the relationship between the human and technics. Most readers thus merely posit that individuation and technics form a whole but fail to find any logical transition between the two texts, or reason to regard them as a coherent project. Ultimately, the presumption that Simondon's theses must be read together may be attributed to the genre of texts which seeks to grasp the essence of a thinker represented by their name, and also to a desire to find a system in the works of a philosopher.[11]

We do not attempt to find the "hidden transition" between Simondon's two major texts or explain their unity in this thesis, nor is our focus the essence of the philosophy of Gilbert Simondon. Rather, we explore the possibility, plausibility and implications of Simondon's conceptualisation of transduction and its relationship to natural scientific thinking. Transduction and scientific thinking are at the heart of Simondon's project in *L'individuation*, but marginal for *Du mode*. In this sense, we largely leave to one side Simondon's philosophy of technics and its political implications (which constitutes another tendency in texts on Simondon's work)[12] and so too, we primarily emphasise the first two parts of *L'individuation*.

The specificity of this thesis affords a closeness of engagement which, we contend, has been lacking in other discussions of *L'individuation* and transduction. Whilst few texts fail to mention transduction or Simondon's engagement with the sciences, most also limit close engagement to the Introduction of that text. There is good reason to engage closely with the Introduction, but we maintain that this must not be at the expense of discussion of the rest of the text. Indeed, the Introduction (and the Conclusion, to a certain extent), offers something of a key for orientation through the rest of the text. It

[11] Barthélémy's (2008) *Simondon ou l'encyclopédisme génétique* neatly encapsulates both of these tendencies.
[12] See, for example, Aspe, B. (2013), Bardin, A. (2015), Combes, M. (2012).

provides a schematic version of the whole argument in *L'individuation*, and clear expressions of certain crucial aspects of the argument which remain opaque elsewhere in the text. Crucially, however, we contend that the broad positions and problems outlined in the introduction are only made possible and plausible in the main body of the text, where Simondon attempts to fulfil the claims of the Introduction.

In this way, transduction is expressed most clearly in its generality in the Introduction, as the term which ought to apply to "any of the cases where an individuation is realised".[13] We read this statement with the upmost seriousness and pursue the possibility and plausibility of the general application of transduction throughout this thesis. But we maintain, nonetheless, that the nature of transduction and evidence for its general application are only supplied in the rest of the text: it is here that the claims of the Introduction are borne out.

Unsurprisingly perhaps, it is the relationship between transduction as it is articulated in the Introduction and its development throughout the text that we find the subtlety and complexity of Simondon's proposition. In this respect, we argue in this thesis that it is through engagement with theory and examples from the sciences that transduction is developed and defended. Whilst the Introduction and Conclusion provide the skeleton for transduction, it is fleshed out through a more subtle conceptualisation in light of examples, which serve both as problematic resources for conceptual resolution but also evidence for the applicability of Simondon's description of individuation.

L'individuation is replete with examples, like crystallisation, of course, but also sub-atomic particles, the tobacco mosaic virus, freshwater hydra, corals, jellyfish, termites and lichen, to name a few. These exemplary beings serve to constitute and confirm Simondon's transductive ontology. It is through the analysis of examples that the concepts for transduction (broadly, of relation, information and becoming) are determined, whilst each example equally serves to demonstrate the sense in which transductive characteristics are shared by many kinds of individuating being.

In this regard, we contend that Simondon's analysis of crystallisation is more complex than it is often presented, serving to articulate the four concepts of transduction which

[13] Simondon, G. (2013), 33.

are maintained throughout the text: limitation, multiplicity, temporality and information. As the text progresses, however, Simondon does not merely reapply transduction to further examples, rather it is conceptually developed in light of new exemplary beings. Thus, the discussion of living beings, in the second part of the text, is not merely an exercise in evidencing the concepts of transduction. Instead, Simondon argues that engaging with diversity in modes of generation, given through theories and examples, forces a further development of transduction. According to Simondon, this produces a conception of individuation which is not limited to a certain kind of being but accommodates any and every living generation.

Through examples we also see the thinking which makes transduction possible, or indeed serves as the foundation on which it is built. As we have said, examples are a resource for conceptualisation and force transduction to adapt as new kinds of being and generation are met with through the text. These examples also constitute and confirm Simondon's analysis, both making it possible and plausible. Examples make the argument *possible* to the extent that their existence or historical appearance changes the way in which operations and beings are grasped, whilst they offer *plausibility* to Simondon's argument as a function of their own plausibility, or the extent to which they are widely accepted and/or they have "proven their mettle". If examples both drive Simondon's analysis and justify his articulation of transduction, then we must ask what makes these examples possible. In short, our response is that examples are made possible by scientific theories and concepts.

It is scientific thinking, then, that we contend produces the theories and examples from which the concepts for transduction are derived. Scientific thought is here conceived as those theories and examples which make Simondon's analysis possible. In contrast to "scientific research" (*Forshung*) considered as a method of testing hypotheses until a theory is considered adequate (in Popper's sense of the term), scientific thought describes the products of such a method. Equally, in contrast to Kuhn's conception of science as divided amongst the trailblazing work of "revolutionary science" - or the production of new theoretical descriptions which overturn fundamental theories - and the quotidian "normal science" - which describes the work of extending and refining paradigms - scientific thought describes what has been produced (and largely accepted). In this sense, we might consider scientific thought as those theories and

descriptions which have "proven their mettle" in Poppers terms, or "paradigms" and the "normal science" and descriptions they make possible in Kuhn's terms.

But whilst research, revolution or normal science attest to scientific work as a moving and historical process, Simondon's argument, we contend, requires a static foundation provided by scientific thought. Scientific thought acts as a historical condition for the possibility of Simondon's argument, and the falsification or overturning of that same condition could make it highly implausible.[14] The tension between the moving and the static in science - between proof, refinement, but also refutation, falsification and overturning - is then carried over to Simondon's work, which requires scientific thought, but may be undermined by the historical movement of scientific thinking. It is in this sense that we refer to scientific think*ing*, stressing the temporary and unfinished nature of scientific thought.

The most significant aspect of scientific thought for Simondon's text is perhaps his engagement with the science of energy, which informs both of his ontologies, and constitutes a significant part of the possibility for transduction. Equally, we demonstrate the sense in which these examples derived from scientific thinking are limits on the creative capacity of individuation. In this way, whilst we argue that preindividuality is an indeterminate energy driving individuation, it is constrained by the exemplary beings in the text. At one level this appears as a natural necessity, a limit imposed on ontogenesis by the laws of nature, and at another, this is more like an epistemological or even technical necessity, produced by scientific research and thinking.

In this regard, we disagree with Deleuze that in *L'individuation* Simondon merely "draws inspiration from the actuality of science" and agree instead with Isabelle Stengers that his philosophy of transduction "rests" on contemporary science.[15] The concepts for transduction are made possible by analysis of theory and examples from the sciences, which also empirically confirm Simondon's argument. The beings that constitute, evidence, and verify transduction are only possible in light of the contemporaneity of science, as Deleuze notes, but these beings are not mere inspiration

[14] As an epistemological condition, even a thorough falsification of a scientific theory cannot render it impossible, but only highly implausible, or we might argue, practically or historically impossible.
[15] Deleuze, G. (2002 [2004]), 124 [89; trans modified]; Stengers, I. (2002), 305.

for transduction, rather, they supply its foundation. Scientific thinking thus makes transduction possible, but as Stengers emphasises, it can equally make it impossible, restrict or specify its application. Transduction stands or falls on the basis of scientific thinking.

It would, of course, be something of a challenge to find a text on Simondon's work which does not mention contemporary science. Our contention, however, is that both the detail and the stakes of this engagement have not been fully grasped. We make a variety of fine-grained analyses of Simondon's engagements with scientific thought which have not interested readers to date, engaging closely with his arguments regarding physical and vital transduction. In this regard, we derive conceptions of relation, information and energy which remain opaque or unexplored in work on Simondon's thought. Whilst many readers propose that Simondon's is a philosophy of "metastability" which engages with "thermodynamics", or that his interest in "information" was informed but also differentiated from cybernetics, these terms often remain indeterminate. We critically discuss the history and meaning of concepts from thermodynamics, information theory and cybernetics, attempting to give clear definitions of their relevance and specificity to Simondon's work. This serves both to grasp the conditions for Simondon's work but also evaluate his contribution.

It ought to be noted that some readers have engaged more thoroughly with Simondon's relationship to scientific thinking, but our contention, nonetheless, is that something significant has been missed. Barthélémy's[16] work is exemplary in this regard, discussing Simondon's critique of substance, his articulation of thermodynamics, potential energy and preindividuality in light of both developments in the sciences and the philosophy of science. Whilst Barthélémy's discussion of Simondon's project as a whole is insightful, when it comes to the role of scientific thinking, he tends merely to detail conceptual similarities rather than explaining the sense in which scientific thinking makes Simondon's philosophy possible. Like Deleuze, Barthélémy's position implies that Simondon drew mere *inspiration* from scientific developments. He does not explain the stakes of Simondon's position: for example, whether potential energy might be a limiting factor for the generality of transduction; if there is more than passing

[16] Barthélémy, J. H. (2008).

resemblance between Simondon's conception of relation and that of quantum mechanics; or if Simondon's position is compatible with that of a thinker like Gaston Bachelard.

Similarly, whilst Pascal Chabot[17] clearly recognises the consistency of Simondon's use of examples (structuring the chapters of his text on individuation according to examples of "the brick", "the crystal" and "coral colonies") he does not draw any critical conclusions from this. Chabot offers admirably clear summaries, but he does not step back from Simondon's text in order to reflect on the extent to which these examples make his argument possible, or indeed, to question the sense in which scientific thought makes these examples themselves possible.

If many celebrate Simondon's engagement with the sciences without thinking its possibility, pointing it out without discussing its justification, Isabelle Stengers' short texts on Simondon are exceptional, arguing that transduction has been - or will be - made impossible by the historical development of physics.[18] In this way, she argues that Simondon's conception of transductive individuation rests on scientific description, but does not achieve the status of a universal description which Simondon claims. Transduction is apt to describe crystallisation, according to Stengers, but it cannot be extended to further scientific descriptions, such as those of non-linear thermodynamics or quantum mechanics. If she is correct, transduction would be restricted to crystallisation, and Simondon's claim for its general application would fail.

Our contention, however, is that Stengers is too hasty and polemical to do justice to the subtlety inherent to her analysis (it engages only very briefly with the first part of *L'individuation* and concludes too quickly that transduction is restricted to linear thermodynamics). In large part, we disagree with her proposition, and the first two chapters of this thesis might be read broadly as both a reflection on and ultimately a rebuttal of her argument. At the same time, however, Stengers is almost unique in critically grasping the stakes of Simondon's position, recognising that transduction is made possible by scientific thinking, which may, in turn, make transduction impossible or at least more specific than Simondon claims. She is correct that transduction rests on

[17] Chabot, P. (2003).
[18] Stengers, I. (2002; 2004).

scientific description, and that it may be falsified or limited to a more particular range of beings by the development of scientific thinking. In much of this thesis, then, we attempt to reckon with precisely this.

The other reader of Simondon who correctly grasps something of this problem is Miguel de Beistegui. Although de Beistegui's conclusions are very different from Stengers', he similarly recognises the extent to which Simondon's philosophy, and for him much of the work of contemporary philosophy more generally, depends on scientific thinking. Both in a brief text on Merleau-Ponty and Simondon and his long study on the history and contemporaneity of ontology, de Beistegui argues that contemporary ontology must engage with science. Primarily, this is because scientific thinking provides access to being which phenomenology cannot. In this respect, Simondon's work breaks with "philosophical questioning rooted in perception"[19] in his engagement with scientific concepts and theories. More generally, de Beistegui argues that the possibility of contemporary ontology requires a move *from* scientific concepts *to* their genetic and differential source. Science, in this way, takes priority over sensation, but also ontology in general. It is thus only in dialogue with and *after* scientific thinking that philosophy as ontology or ontogenesis is possible today. De Beistegui argues without hesitation that today ontology requires scientific thinking, which is a demand that both Simondon and Deleuze recognise.

It is in part this shift from the primacy of perception to that of scientific concepts - an empirical shift - which interests us in this thesis. To claim this, as de Beistegui does, is to a certain extent to argue as Stengers does (albeit through more subtle and patient reading). Whilst Stengers reads Simondon with a hammer, de Beistegui reads Simondon and Deleuze with the care that they deserve. It is something like the tension between Stengers' and de Beistegui's claims that drives much of the thinking in this thesis: that Simondon's ontology is dependent on scientific thinking, which may both be a necessity and a constraint, constitutive of its contemporaneity and its possibility, but at risk of conceptual rectification by the movement of scientific history.

The first chapter of this thesis discusses scientific and philosophical conditions for the possibility of transduction in Simondon's work. We propose here that the meaning of

[19] De Beistegui, M. (2005), 109.

"transducer" from the field of electronics - a device that transforms energy from one form to another - provides a starting-point for understanding transduction. In this way, we argue that the quasi-universal reach of transduction - to "any" individuation - is founded on the universality of energy, its equal application to matter and life, to physics, chemistry and biology. We contend, equally, that Simondon's relational critique of substance rests on conceptual developments in biology and philosophy in the eighteenth and nineteenth centuries, centred on the presupposition of relation for life. Simondon's contribution, in this regard, is to found his conception of relation on the requirement of available energy for the being of beings, rather than considering relation merely perceptually constitutive.

If the first chapter lays out the scientific and philosophical sources for transduction and its broad conceptual positions, the second engages with the fine detail of Simondon's argument in *L'individuation*. Here it is maintained that Simondon's work rests on his use of example, which is not as simple as his "paradigmatic method" suggests. Crystallisation is discussed in detail here, drawing out what we maintain are the key concepts of transduction. Whilst crystallisation is the prime example for *L'individuation*, however, we contend that transduction is conceptually developed throughout the text. In this way, in this chapter we pay close attention to the constancy and progression of Simondon's expression of transduction through his examples and problematisation of living beings.

With the fundamental aspects of transduction in hand, chapter three discusses the sense in which it can describe individuation or singularity. Simondon's conception of preindividuality is key in this regard, functioning as a source for indeterminacy in being. If a principle of individuation completes the series of determinations, descending from genus to *infima* species and concluding with individual, preindividuality is almost the opposite, a *source* for indeterminacy. Transductive individuation, then, involves a creative or inventive mediation of necessity, individuating in the margin of indeterminacy left by natural necessity. In this way, we argue that Simondon's examples act as specific descriptions within which an individuation has a margin for differential becoming which is driven by preindividuality. Unwittingly perhaps, Simondon thus limits creativity or difference to specific descriptions in *L'individuation*. This description is then counterposed to that of technical genesis in *Du mode*, which presents an image of

becoming that accommodates both the invention of a species (a technical lineage) and its progressive evolution (concretisation).

Finally, chapter four asks after the source of what is described in chapter three as "specific descriptions" and "natural necessity". With this we return to some of the themes of the first chapter, discussing the foundational role of scientific thinking, only seen from a different angle. Here it is emphasised that Simondon's philosophy is not critical of induction and deduction as is sometimes described; rather, transduction rests on the products of this kind of thinking, which produce scientific descriptions used in examples throughout *L'individuation*. Returning once again to the nature of examples, it is argued that the necessity of their scientific constitution exerts specific limits on the creativity of transduction. In this regard, we question whether the constraint set by scientific thinking is equally at work in Deleuze's development of Simondon's position. Ultimately, this discussion boils down to whether scientific thinking makes possible and constrains the conditions and results of generation (the virtual and the actual) or whether, in a more Bergsonian sense, the virtual is considered continuous and in excess of the actualities of science. Finally, discussing Gaston Bachelard's early essay on approximation, we propose that both Simondon and Deleuze may underplay the scientific foundation of their work, and more significantly, underestimate its incessant differential movement.

Chapter one - A new word for everything?

It is something of an irony that transduction is a universal description of individuation, or a term which seems to express the generality of singularity. This is not an irony which begins with Simondon's work, however, and perhaps inheres in any philosophy which takes singularity to be in some way both existent and explicable. This irony is then further intensified if all beings are thought to be individuals. Indeed, if everything is individual and "individual" an appropriate term, then it would appear to be the most numerous category, since it describes every being, including those subsumed under different genera. These are not necessarily novel reflections, but this irony or tension pertains nonetheless to Simondon's attempt to rejuvenate an ancient problem, even if transduction is not a category. We return to this network of problems throughout this thesis, concentrating on particular aspects in this chapter.

As the title of this chapter suggests, we discuss the novelty of the term transduction, and Simondon's attempt to provide a definition with universal reach. We attempt to demonstrate both the newness and the generality of transduction, but also to delineate its history and its limitations.

We begin with Simondon's aim to express an operation universal to branches of natural science, which he views as a cybernetic method and a philosophical task. We then reflect on the electronical-technical and cybernetic definition of transducer: a device which converts energy from one form to another. This begins to articulate the meaning of transduction - the operation that Simondon argues is general to branches of natural science - and sets the scene for our discussion of the universality of conversions of energy later in the chapter. Next, we turn to Simondon's critical discussion of hylomorphism, which he admires and imitates as a universal operation expressed according to a paradigm, but criticises for its exclusion of relation and energy. We then discuss the role of both of these excluded elements - relation and energy - focussing particularly on disciplinarity, history and generality. From this perspective, we briefly discuss substantial relation in the twentieth-century French and German context, according to a range of scientific and philosophical terms: *milieu, environment, circonstances, Umwelt*, *in-sein*. This works both to temper Simondon's apparent novelty,

but also provides a backdrop against which his contribution might be better judged and recognised. Finally, we discuss Simondon's relationship to the science of energy, which in certain respects, draws together all of the elements hitherto-discussed in this chapter. Within this discussion of energy, first, we discuss the increasing acceptance of thermodynamic principles and descriptions across different branches of science, paying particular attention to the history of the inclusion of energy as fundamental for living processes or indeed for life. Second, we argue that negentropy provides a means to limit the beings to which "transductive individuation" applies. Third, we reflect on the distinction between energy and information.

1. A theory of conversions, "a universal allagmatics"

In the introduction to *L'individuation* Simondon writes that transduction

> can be used to think the different domains of individuation: it applies to any of the cases where an individuation is realised [*se réalise*], demonstrating genesis from a tissue of connections founded on being.[20]

The passage expresses, in compressed form, many of the key aspects of Simondon's philosophy of transduction as he articulates it in *L'individuation*. It anticipates the structure of the text, which is divided according to "different domains of individuation", and the basic ontogenetic claim regarding individuation - "genesis from a tissue of connections founded on being" - (even if it is rather enigmatically put). Most significant of all is that transduction is here expressed very clearly as a universal description of individuation: it "applies to any of the cases where an individuation is realised".

If transduction describes "any" individuation, the obvious question is whether transduction is simply another word for individuation. If transduction is simply a synonym for individuation, then it would not make any contribution to the task of thinking individuation. It is true that in *L'individuation* transduction and individuation are often drawn together to the point of indistinguishability or expressed as synonymous, but we contend that they are distinct, nonetheless. Indeed, Simondon

[20] Simondon, G. (2013), 33. Reading "manifestant la gènese d'un tissue de rapports fondés sur l'être" as "genesis *from* a tissue of connections," rather than the genesis *of* a tissue of relations, as there are connections or links (*des rapports*) before individuation, as predindividual being. Also, more generally, Simondon prefers "relation" to "rapport" to describe individuation (see, for example, ibid., 68).

writes above that transduction "can be used" to think any individuation, suggesting that the term is exogenous and perhaps prior to the philosophy set out in *L'individuation*. In what follows we express the distinction between transduction and individuation according to its use: first, the method of its application, according to analogies which identify operations shared by different beings proper to different branches of science; and second, the transformation of the meaning of "transducer" in order to be applied as "transduction" to individuation.

Although cybernetics is primarily an object of criticism in Simondon's texts, the use of transduction to apply to a wide range of disciplines and their specific beings owes a great deal to his reading of cybernetics. In particular, Simondon derives a conception of operational analogy from cybernetics, which identifies operations or processes enacted by otherwise different beings. In a range of early texts (written in the early 1950s), Simondon demonstrates a preoccupation with the way that cybernetics functions as a "technique"[21] that links particular sciences by making operational analogies between beings within their particular remit. In this way, cybernetic operations such as feedback, homeostasis and behaviour apply by analogy to both machines and living beings.

Reflecting on the relation between cybernetics, science and philosophy, Simondon argues that cybernetics is a "technique" which draws operational equivalences or analogies between different beings grasped by particular branches of science. In this sense, cybernetics does not produce objective descriptions of beings, effects or laws, but instead takes descriptions from the sciences and finds equivalent operations for otherwise different beings and different branches of science. This is a technique Simondon refers to as "analogical induction" or "cybernetic induction".[22] He argues thus that "Cybernetic induction does not suppose the structural identity of the beings that it brings together [*réunit*], but only the *functional equivalence* of their operations".[23] Two beings, then, may be specifically different, but operate in the same way, nonetheless. Hence, for example,

[21] The two texts are "Cybernétique et philosophie" and "Épistémologie de la cybernétique", both written in 1953. Simondon, G. (2016), 35-68; 177-200.
[22] Simondon, G. (2016), 191.
[23] Ibid.

> When cybernetics, in its inductive procedure, unites the phenomenology of a mental illness and the phenomenology of the functioning of an electronic amplifying relay, it does not affirm that the structure of the mind and the structure of a device composed of conductors, resistances, capacitances and impedances are the same: it only declares that the operation of pathological functioning of the mind and the operation of the amplifier - of which the counter-reaction or the positive reaction produce an auto-oscillation - are the same because they are functionally equivalent. This functional equivalence signifies operational analogy, the analogy being an *identity of relations* [*rapports*] and not a relation of identity.[24]

A functional equivalence or operational analogy describes the sense in which there is an identical operation enacted by two different beings which are, in turn, grasped by two different particular sciences. The cybernetic proposition, according to Simondon, is that a mental illness and an amplifying relay are operationally identical, even if the beings which operate - a brain and an electronic relay amplifier - are very different. Such an analogy identifies the same operation in different specific beings, but also in different branches of science which take a specific being as their object. There is a functional equivalence or operational identity, then, between the disciplines of electronics, on the one hand, and neurology, on the other, each with their specific beings (relay amplifiers and brains, respectively).

Operational analogy is indeed a crucial part of cybernetics, particularly the identification of homeostasis for machines and organisms. For example, in a significant early cybernetic text, Arturo Rosenblueth, Norbert Wiener and Julian Bigelow make an analogy between machines and organisms, arguing that "a uniform behaviouristic analysis is applicable to both machines and living organisms, regardless of the complexity of the behaviour".[25] In Simondon's terms, "behaviour" is the operation which is identical across machines and living organisms, mechanology and biology. In another text, Wiener offers the example of intention tremors "associated with injury to the cerebellum"[26] (which is quite similar to Simondon's example). Wiener exemplifies two

[24] Ibid.
[25] Rosenblueth, A., Wiener N., Bigelow, J. (1943), 22.
[26] Wiener, N. (1989), 166.

intention tremors: one which involves increasingly wide swings in the hands during goal-seeking action (like reaching for a glass); and another, almost opposite tremor (associated with Parkinson's disease) which involves shaking whilst at rest, which then ceases during purposive action. For Wiener, these intentional tremors are operationally identical to feedback mechanisms in machines. Indeed, with regards to his examples, a machine was purpose built with the two aforementioned functions - intention tremors and tremors whilst at rest - which could demonstrate the breakdown of these voluntary feedback mechanisms. Two different beings - machine and organism - enact the same operations (pathological feedback responses associated with purposive action). An analogy can be drawn between these operations, but not between the beings.

Simondon's analysis is less successful, however, in distinguishing cybernetics and science. In this way, he attempts to map the structure and operation pair onto science and cybernetics respectively, which is tenuous at best. Indeed, this amounts to the proposition that the natural sciences of the twentieth and twenty-first century do not study operations, processes or conversions, which is a claim that Simondon himself seems to recognise is not credible.[27] A strict distinction between science and cybernetics also requires that the latter does not engage in its own study of beings (or structures), or that it only attempts to grasp analogies between branches of knowledge.

To suggest that the natural sciences study structures and *not* operations may be highly implausible, but we might understand this distinction as Simondon's proposition that cybernetics works with already constituted scientific theory and description. In this sense, cybernetics comes after the sciences, working with their descriptions and uniting them according to operational analogies. In this way, he argues that "it is thus not necessary to begin by defining the object of Cybernetics, as one would define the object of crystallography or of optics".[28] Cybernetics does not produce knowledge about its proper object, because it does not have one. Rather, it works with already constituted scientific descriptions, or even based *upon* them, in the study of operations. Cybernetics is thus an "inter-scientific technique".[29] It is not a "utilitarian technique", or one of industrial production which uses scientific knowledge for a "social or affective" end,

[27] Simondon himself even notices this elsewhere, proposing that, like cybernetics, the sciences study "conversions". Simondon, G. (2016), 184.
[28] Ibid., (2016), 42.
[29] Ibid., 187.

using scientific knowledge as a mere instrument for some productive end.[30] It is rather a practice "guided by scientific normativity" which links already constituted knowledge by operations common to two or more branches of science.[31]

If the distinction between science and cybernetics is overstated in these texts, it is worth remembering that the latter was, at the time of writing, a very new discipline (if indeed, we can call it that). Thus, Simondon's reflections are perhaps better read as propositions for the future of cybernetics rather than analyses of its actuality. This also tells us something about the work of *L'individuation*, which is structured according to different branches of science - physical, vital, psychic - which are united by the operation of transductive individuation. To this extent, *L'individuation* might be read as an attempt to fulfil the methodological trajectory Simondon sets for cybernetics in these texts.

Much of the contrast Simondon draws between the sciences and cybernetics centres on the particularity of the former and the generality or universality of the latter. More significant than the distinction between structure and operation is the sense in which cybernetics might grasp operations general to particular branches of science. In both texts he reflects on Norbert Wiener's comments in the introduction to *Cybernetics,* that "the most fruitful areas for the growth of the sciences are those which had been neglected as a no-man's-land between the various established fields".[32] He argues that if Wiener means by this that the cybernetic task is to "conquer" this no-man's-land as "a new objective domain", then he is mistaken. Instead, cybernetics is an art of drawing existing objective domains together according to analogical operations. The aim of cybernetics is not discovering new land or taking it from the sciences, but "it would be instead a complementary view of the same world", as Simondon puts it.[33] Cybernetics should thus primarily complement rather than challenge the work of the sciences, finding analogical (and thus general) operations between particular scientific descriptions.

[30] Ibid.
[31] Ibid., (2016), 187.
[32] Wiener, N. (1962), 2.
[33] Simondon, G. (2016), 185.

Simondon recognises there has been some inter-scientific collaboration or trans-disciplinarity prior to the advent of cybernetics (in the work of physico-chemistry or psycho-physiology, for example). But he contends that the future of cybernetics should seek even greater generality, signalling "the necessity for a general cybernetics, a cybernetic theory above these particular cybernetics".[34] To express the universal direction in which cybernetics ought to travel, Simondon offers the analogy of James Clerk Maxwell's theory of electromagnetism, which involved his deduction of universal equations for the phenomena of light, electricity and magnetism. In the same way that Maxwell's equations unified the particular sciences of light, electricity and magnetism and their respective laws in a single formula, Simondon argues that a "general cybernetics" would be capable of "completing the formulae of each particular cybernetics by a structure capable of universalising the system of formulae, rendering it valuable for all particular cybernetics".[35] A general cybernetics, then, ought to supply a description which draws together the particular sciences in something like Maxwell's single formula for electromagnetism.

The operative term for a universal cybernetics is "allagmatics" [*allagmatique*], in the two texts that we have been discussing, and in a third undated text to which we now turn. In this latter text, in fact entitled "Allagmatique", Simondon writes that

> Cybernetics marks the beginning of a *general allagmatics*. The programme of *allagmatics* - which aims to be a universal Cybernetics - consists in making a theory of the operation.[36]

The passage is a little elliptical, but the core meaning is clear: cybernetics is the beginning of an allagmatics; allagmatics is a theory of the operation and its programme is universality. Indeed, if cybernetics is already a theory of operations, analogically unifying particular natural sciences according to operations, then the task of allagmatics is to universalise cybernetics.

[34] Ibid., 184.
[35] Ibid., 183.
[36] Simondon, G. (2013), 531 [italics original].

In a similar vein, reflecting on the coining and the meaning of the word "cybernetics" in "Épistemologie de la cybérnetique",[37] Simondon suggests that "a word like *allagmatics* (theory of conversions) would be more universal".[38] Thus, rather than Wiener's metaphorical etymology of control and orientation which produces "cybernetics", a "theory of conversions" is superior because it is more general in its application.

This describes a movement of ever greater generalisation: from particular sciences to technical generalisations through operational analogies (the actual work of cybernetics), which in turn produces "particular cybernetics", which ought to be further generalised or universalised by an allagmatics. In this way, in the opening paragraphs of "Allagmatique" Simondon writes that the discipline of allagmatics may need to "define the great categories of operation", but a few lines later that "perhaps the theoretical goal would be better attained if one single fundamental type of operation could be defined".[39] The latter is precisely the aim of *L'individuation*, we contend, the expression of one fundamental operation: transduction.

At this point it is worth stepping back from our analysis for a moment in order to take stock of what we have discussed, particularly since many of the aspects of these 1953 texts are reconfigured in the thesis submitted as *L'individuation* in 1958. We have seen that Simondon affirms cybernetic analogy or cybernetic induction as a technique for drawing together beings from particular sciences according to functional or operational equivalences. We also saw that for Simondon, as for Wiener, cybernetics works *with* already constituted sciences. As an "inter-scientific technique", cybernetics is not in competition with particular branches of natural science, nor is it empirically prior to or more fundamental than their objective descriptions.

In this sense, the universal cybernetics Simondon proposes is like an inversion of Heidegger's ontological difference. Simondon and Heidegger both attempt to reconfigure the particularity of the sciences - each divided from one another according to their proper being - with regards to something more fundamental to and shared amongst them. According to Heidegger, however, philosophy must renew ontology in

[37] Cybernetics was coined by Norbert Wiener from the Greek *κυβερνητική* or "governance" with an etymological allusion to James Clerk Maxwell's text "On Governors". Wiener, N. (1948) 11-12.
[38] Simondon, G. (2016), 184.
[39] Ibid., (2013), 528.

order, not only to ascertain the conditions for the possibility of the diverse ontologies of the natural sciences, "but also for the possibility of those ontologies themselves which are prior to the ontical sciences and which provide their foundations."[40] Heidegger's aim is to grasp the same conditions which make possible the plurality of the sciences, a task which is more fundamental than, prior to, and separate from (though ultimately compatible with) natural scientific ontologies. Simondon, on the contrary, is proposing that a fundamental operation must be found that is general to the particular sciences but founded on the empirical descriptions of those sciences. If we remember Simondon's analogy with the equations for electromagnetism, Maxwell's contribution was to bring together already constituted scientific descriptions of electricity and magnetism in a single formula.

It is also worth noting here that this analogy works with operational identities, or as Simondon puts it, with "identities of relations and not relations of identity".[41] This is the same analogical movement - "analogical induction", even - that we find in *L'individuation*, whereby a basic operational image of transduction is transposed across different scientific domains. Indeed, the phrase quoted above is repeated in *L'individuation* in order to emphasise that transduction describes a relation, or better, a necessarily relative being, rather than a structural or objective description. Hence, this analogical identity is one of operational relations rather than beings; particular sciences and their proper beings differ, but their operations are the same, according to Simondon.

That this kind of analogy is attributed to cybernetics may also serve to redress the notion that Simondon's conception of analogy in particular and work in general are in contradistinction to cybernetics. Simon Mills, for example, mistakes Simondon's criticism of structural analogies (those phrased as "relations of identity" above) for a criticism of cybernetics, and organises a whole subsection of his text according to what he takes to be Simondon's critique of cybernetic analogy.[42] In fact, from these early texts it is clear that Simondon regards cybernetic analogy as operational or relational (an identity of relations), and it is precisely that which he affirms in his own method.

[40] Heidegger, M. (1962), 31.
[41] Simondon, G, (2013), 533.
[42] Mills, S. (2016), 24-5.

According to his two 1953 texts, Simondon's analogical method in *L'individuation is* cybernetic.

Finally, however, whilst Simondon's own position owes a great deal to cybernetic inspiration, he distinguishes cybernetics from his own project, allagmatics, in terms of universality. Whilst he notes that cybernetics makes operations general or universal to particular sciences and their objects, his aim is to provide a description more general than cybernetics. In one draft this involves two operations, modulation and crystallisation, but *L'individuation* privileges transduction, which incorporates both.[43] Thus, we contend that transduction is the "single fundamental operation" Simondon describes in "Allagmatique". Indeed, as he writes later in *L'individuation*, transduction "can be used to think the different domains of individuation: it applies to any of the cases where an individuation is realised".[44]

Transducers and transduction

We have explored the notions of analogy and universality that Simondon derives from cybernetics, then, and briefly discussed them with regards to the universality of transduction as stated in Simondon's introduction to *L'individuation*. Before we turn to the conceptualisation of transduction in *L'individuation*, first we ought to linger for a moment on the meaning of the word transduction outside of Simondon's work, as it is found in texts in the fields of cybernetics and electronics.

To a philosophical audience, transduction may be unfamiliar and perhaps appear enigmatic, but to readers versed in electronics the term is likely more familiar due to its similarity to "transducer". Transducers are not exotic devices within cybernetics and electronics, and they are in fact so numerous and ordinary that they are sometimes left undefined in texts from those disciplines.[45] The ordinariness of transducers may go some way to explaining the absence of an explanation of the term on Simondon's part, who would, in this sense, make a conceptual development of the term assuming the readers' familiarity with its original meaning. This could also explain his proposition

[43] Simondon, G. (2013), 529-536.
[44] Ibid., 528; 33.
[45] In Wiener's and Ashby's texts, for example, transducers are common though never carefully defined or thematised.

that transduction "can be used" to think individuation, implying that transduction is exogenous to the study of individuation and thus perhaps also to philosophy.

The noun "transducer" is perhaps most at home in the field of electronics, but its meaning stretches far beyond that; indeed, its meaning is likely familiar in some sense, even if it does not appear so at first. Definitions two, three and four from the entry "transducer" in Rudolf Graf's *Modern Dictionary of Electronics* are helpful in this respect. Graf states that a transducer is:

> 2. A device, component, machine, system, or combination of these that converts energy from one form to another. The energy may be in any form, such as electrical, mechanical, acoustic, etc. …
>
> 3. A device used to convert physical parameters, such as temperature, pressure, or weight, into electrical signals.
>
> 4. A device that converts information from one physical form to another. Examples include the phono cartridge (mechanical to electrical), speaker (electrical to acoustical), and microphone (acoustical to electrical).[46]

According to Graf's definition, then, the work of a transducer is the conversion of energy. A transducer converts energy from one form to another, from electrical to thermal energy, for example. Thus, a phono cartridge is a transducer: it receives mechanical energy (or information) from the movement of an engraved disk and converts it into an electrical signal. An amplifier and speakers are also transducers, which convert electrical energy into kinetic energy in the movement of a speaker cone, producing sound waves. We might note, however, that energy and information are not clearly distinct in Graf's definitions. Indeed, the forms of energy in definition 2 (electrical, mechanical, acoustic) become "physical" forms of information in definition 4. Properly speaking, they are all forms energy. Here "information" only serves to confuse

[46] Graf, R. F. (1999), 792. We might notice that energy and information, in the definitions above, are not clearly distinct. The forms of energy in definition 2 (electrical, mechanical, acoustic) become "physical" forms of information in definition 4. Now, to a certain extent this makes sense, as an electrical signal can be described with electrical energy and the movement of a speaker can be described with kinetic energy, whilst the conversion of an electrical signal to the movement of a speaker cone may also be a process of transferring information, that is, something which can rendered more or less accurately.

the definition (this is a common confusion, and one which we will discuss in the final section of this chapter).

A transducer, then, "is a device, component, machine, system… that converts energy from one form to another". Remembering that allagmatics was defined as "a theory of conversions" and that cybernetics finds analogical operations (or conversions) for machines and living beings, we begin to get a sense of what Simondon is attempting to do with the term transduction. As we will see later in this chapter, energy is also crucial for transductive individuation, both since individuation requires energy in order to take place and because the theory and laws of energy are accepted across the branches of science - physical, vital and psychic - on which *L'individuation* is founded. As this thesis develops, too, we will see the sense in which Simondon formulates transduction from transducer, such that an individuation is said to be "transductive" or indeed a transduction, whilst beings are themselves transducers. Simondon uses the term transduction to describe the genesis of a being, an operation that requires the conversion of energy, whereby the *transducer* is the ontogenesis itself; individuation involves the genesis of a transducer by transduction.

2. A new universal paradigm: replacing hylomorphism

Simondon's intention, as we are beginning to see, is to express the universality of individuation using the concept of transduction in order to make an operational analogy that emulates cybernetic analogies. One of the reasons that a new, or exogeneous term is required for individuation, according to Simondon, is that hitherto attempts to articulate individuality have made the same error, beginning with an already constituted individual, and working backwards trying to explain its individuality. Ancient atomism posits individuality as already given and eternal - atoms have no beginning and no end - and thus if the atom is the individual, it has no genesis to speak of. Similarly, hylomorphism begins with a constituted individual and attempts to explain the source of its individuality rather than its coming-into-being, focussing on what it takes to be the *constituents* of genesis (matter, form, principle) rather than its genesis proper. Both, according to Simondon, attempt to grasp an individual which is already constituted, whose genesis has already happened. Simondon's interest, on the contrary,

is genesis itself, the real operation of coming-into-being, not the being which results from it.

The critique of both atomism and hylomorphism in *L'individuation* function primarily as a means for contradistinction, for broad contrast with the novelty of transduction. There is little textual analysis of historical variants of atomism and hylomorphism, and instead they are used as polemical distinctions in the introduction and as a means for negative determination of transduction later on in the text. Atomism is the subject of Simondon's critique of the sense in which relation is conceived as merely accidental (that relation is unnecessary or optional for beings). Hylomorphism, then, is criticised for excluding mediation and duration in individuation, but also for attempting to explain individuality by categorial descent (from genera to an *infima species* to an individual).

Simondon's critique of the atomic individual has significant positive results in his conception of relation, offering a clear example of accidental relation against which the substantial relation of transduction can be contradistinguished, which we will discuss later in this chapter. There is little doubt, however, that hylomorphism is a more significant and regular theme - it is Simondon's "principal adversary", as Barthélémy puts it.[47] The most obvious reason for this is that hylomorphism is closer to a conception of individuation proper, for Simondon, whilst atomism assumes fundamental individuation has already taken place.[48] Thus, if Simondon wants to produce a new conception of individuation it is reasonable that he will need to distinguish it from the hylomorphic conception.

Simondon also has a certain methodological admiration for hylomorphism, however. Indeed, he sees it as an attempt to express individuation according to a universal operation using a paradigm example, which is precisely what he affirms about cybernetics, and what he will go on to do with crystallisation. Thus, he notes the "remarkable capacity for generalisation" of the matter and form pair derived from a "technical operation".[49] Indeed, as Simondon reads it, hylomorphism involves the

[47] Barthélémy, J. H. (2005a), 61.
[48] The significant lacuna in Simondon's analysis of atomism is that he does not discuss the sense in which beings may come-into-being through an aleatory composition of atoms.
[49] Simondon, G. (2013), 39; 40.

abstraction of an operation from productive technical process which is universal and can be applied analogically to various different beings and within different domains.

Hylomorphism is a schema or operation which, like cybernetic operational analogy, applies to different beings proper to different branches of knowledge. Simondon's analysis focusses on the "technical operation" of brick making, involving clay and a mould, which are abstracted as matter and form. For Simondon, hylomorphism rests on an operation abstracted from technical production, but which may be applied to a great variety of operations - such as technical production, the generation of living beings, the relation between body and soul - if not any and every operation. In this sense, whilst beings may be different - bricks and statues on the one hand, cuttlefish and humans on the other, for example - the operation of their coming-into-being is the same. Like cybernetic operations, the hylomorphic schema is universal to different beings which are proper to different branches of knowledge:

> It is not only the clay and the brick or the marble and the statue which can be thought according to the hylomorphic schema, but also a great number of facts of formation, genesis and composition in the living world and the psychic domain. The logical force of this schema is such that Aristotle was able to use it to support a universal system of classification which applied to the real as much to the logical path as to the physical path, by ensuring the accordance between the logical order and the physical order, and authorising inductive knowledge. Even the relation between the soul and the body can be thought according to the hylomorphic schema.[50]

Simondon admires the hylomorphic schema for its capacity for generality. It is apt for thinking operations across diverse branches of science such as logic, change (Aristotle's "physics"), biology and psychology. It can also be used for thinking various operations - formation, genesis, composition - as well as beings or their structures, through the operation of classifying induction. Indeed, few would disagree that Aristotle's hylomorphism has an extraordinary capacity for diversity, and great "logical force".

[50] Ibid, 39.

As a schema for genesis or individuation, derived from one but applicable to many, if not all, branches of knowledge, hylomorphism is something Simondon would like to imitate.[51] But there are a number of features of hylomorphism which make it incapable of grasping genesis. Before discussing Simondon's criticism, though, it is worth noting that the "hylomorphism" discussed in *L'individuation* can appear largely his own invention. Indeed, whilst some of the broad issues from the Aristotelian tradition are apparent - primarily, whether the principle of individuation is in the matter or the form and whether there is something underlying substantial genesis - they are faint, particularly in the section ostensibly dedicated to hylomorphism. In the subsequent section we will try to assess more carefully the credibility and range of Simondon's critique of Aristotle.

In the chapter entitled "Forme et matière",[52] Simondon argues that matter and form alone cannot account for genesis; rather, they obscure genesis proper, the moment of mediation when clay and mould meet. What is crucial is the energetic relation between matter and form in the process of taking form, but this is rendered almost invisible by the instantaneous hylomorphic description of genesis. The passage runs through the conditions for the production of bricks by moulding clay, arguing that matter and form alone do not account for genesis, but instead a more protracted process of preparation is required to ready matter and a mould for mediation. But whilst the section begins with mention of Aristotle (as we saw in the passage above), there is no further discussion of Aristotelian, or indeed any other hylomorphism. Instead, it lays out many of the key aspects of the transductive problematic that are worked through later in *L'individuation* - relationality and energy, most significantly.

Simondon goes some way to explaining the absence of Aristotle in all of this in the third section - "Limites du schème hylomorphique"[53] - in which he argues that the

[51] Barthélémy goes so far as to argue that Simondon's expression of hylomorphism as an example or paradigm (brickmaking) and a schema (matter/form) can be transposed directly onto transduction, for which crystallisation would be the paradigm and transduction the schema. Barthélémy acknowledges that "Simondon does not make the distinction" between paradigm and schema when it comes to hylomorphism and transduction, which is for "reasons conceptual clarity" (Barthélémy, J.H., 2008, 64). A clearer way to grasp the distinction, however, is that whilst Simondon refers numerously to "the hylomorphic schema", this is precisely what obscures the operation and thus there is not a transductive schema, but a transductive operation.
[52] Simondon, G. (2013), 39-67.
[53] Ibid., 48-51.

hylomorphic grip on thinking genesis can be traced back to an analogy with the social relation between master and slave. In this way, the master takes on the role of a form imposed on the passive labour capacity of a slave. Thus, according to the sequence of the first two sections of *L'individuation*, first hylomorphism is proven wrong for ignoring the mediation necessary for genesis, and second, Simondon explains why - in spite of this erroneousness - it has retained dominance over the thinking of genesis. In this way, rather than conscious philosophical ingenuity on Aristotle's part, hylomorphism is an expression of a social relation which is presented as *the* description of genesis whilst simultaneously concealing its true origin.

Jean Hugues Barthélémy defends Simondon in this regard, arguing that he makes a sound interpretation of what he considers the "unconscious" hylomorphic paradigm.[54] The origin of hylomorphism in social relations would then also explain its "force" and longevity which Simondon questions in the opening passage of the section, according to Barthélémy. This is certainly an interesting proposition, and Barthélémy's careful commentary on this section of *L'individuation* remains one of the most accurate and edifying of the many glosses on Simondon's critique of hylomorphism. The difficulty with this argument, however, is that he concludes that Simondon's interpretation is justification enough. Barthélémy offers no further discussion or evidence for the claim that hylomorphism is derived from a social unconscious of domination, or crucially whether it has undergone historical change between the time of Aristotle's writing and today. It is not clear, for example, that a thermodynamic expression of transductive genesis such as Simondon's is any less the production of an unconscious social relation. It may not be that of master and slave, but instead a relation of profit and work, reflecting the central thermodynamic concepts of entropy and work. Equally, neither Simondon nor Barthélémy reflect on whether the problem is instead linguistic and psychological, having as much to do with purposiveness in human life and linguistic technique and categorisation; languages and industrial technical production are, after all, structured according to forms indifferent to singularity. Above all, if one disagrees with Simondon's presentation of hylomorphism, and thinks Aristotle has anything to

[54] Barthélémy, J. H. (2008), 58.

add, Barthélémy's discussion remains largely expository, and does little to question or defend Simondon's position.

Neither matter nor form, but mediation

Leaving the hylomorphic unconscious to one side, there are two aspects of Simondon's critique of hylomorphism which demand more attention in light of Aristotle's position. First, Simondon argues that the principle of individuation is neither in the matter nor the form, but in mediation or communication between matter and form; and second, he argues that hylomorphism seeks to explicate individuated or actualised individuals, but ignores individuation proper, which may be a process that lasts as long as the individual does.

The problem of the assignation of a principle of individuation has been a long running problem within Aristotle scholarship, with different interpretations fuelled in part by different passages which seem to state various conflicting positions. Traditionally the problem turns on ascertaining whether the principle of individuation is in either the matter or the form of an individual (which is considered a composite of the two).

If the same matter cannot be shared by two individuals at the same time, and form is only ever specific (or individual forms are impossible), then matter is deemed the principle which gives individuality to an otherwise specific form in a compound being. On some occasions, Aristotle seems to state exactly this. For example:

> when we have the whole, such and such a form in this flesh and in these bones, this is Callias or Socrates; and they are different in virtue of their matter (for that is different), but the same in form; for their form is indivisible.[55]

Callias and Socrates are compounds of matter and form, they are the same in species - which cannot be divided further than the *infima species*, human - but differ according to their matter. Thus, from this passage it would seem that form provides the species whilst matter individuates.

[55] Aristotle (1991), *Met.* 1034 a5-8.

However, Aristotle often presents matter as pure and featureless potential, and does not describe it as a "this" (*tode ti*) or an individual.[56] In this way, it would seem that form is individual, and the principle required to make matter - otherwise potential and indistinct - actual and individual. Aristotle writes, for example, that "form or essence, which is that precisely in virtue of which a thing is called a *this*" and "by matter I mean that which, not being a '*this*' actually, is potentially a '*this*'".[57] The first passage suggests Aristotle holds that forms are what give individuality to otherwise non-individual things, whilst the second suggests that matter is merely potentially individual, requiring the actuality, or actualising force of form.

A third option, however, has been noticed by some who argue that neither matter nor form can be said to be the principle of individuation as individuals are composites, and thus require *both* matter and form.[58] Even if a form can be a *this* or an individual, in order to exist they must be materialised (excluding those few forms which, for Aristotle, exist without matter). Indeed, as the vast majority of Aristotle's individuals are composites of matter and form - informed matter, materialised form - it seems to make little sense to argue that only one part individuates whilst another does not. Further ballast is given to this position by dint of the fact that Aristotle often refers to *thises* or individuals as composites, sometimes contrasting forms with *thises*.[59]

This leads some to the conclusion that matter and form are linguistically or conceptually distinguishable, but not causally so. Matter and form might thus be picked out to explain the features of an individual, but this does not give them a separate role in genesis. Simondon argues something similar, proposing that if either matter or form is given as the principle of individuation, then what gives individuality would already be individual before the event of individuation. The significant difference, however, is that whilst the conceptual distinction between matter and form in a composite individual assumes that the individual already exists, Simondon's critique is focussed on the

[56] For example: "matter is potentiality, form actuality", Aristotle (1991), *De An.* 412 a9-10. Whether uninformed or "prime matter" actually exists is another enduring discussion in Aristotelian scholarship.
[57] Aristotle (1991), *De An.* 412 a8-9; *Met.* 1042 a26-7.
[58] See, for example, Regis, E. (1976).
[59] For example: "the entire *this* is Callias or Socrates, as in the case of this bronze sphere", Aristotle (1991) *Met.* 1033 b24-5, which Edward Regis (1976) points out is "*contrasted* with form or essence alone", for example: "form signifies a such, and this is not a *this*"; "there is some matter in every thing which is not an essence and a form by itself but is a *this*"; 163 [italics original]; Aristotle (1984), *Met.* 1033 b21-2; 1037 a1-2.

coming-into-being of an individual. Indeed, he is attempting to overcome the overemphasis on the constituted individual. Simondon really doubles the problem of individuation, since for him it requires explaining both the genesis of beings but also their individuality, which for him, is a genesis.

Even those who maintain that Aristotle's individuals are composites assume their genesis, according to Simondon's contention. Edward Regis Jr, for example, argues that for Aristotle the existence of individuals is "not something requiring explanation but something which as a first principle is presupposed by and the basis of all explanation".[60] Regis does not seem to notice, however, that this only avoids the question regarding the principle of individuation by making individuals themselves principles. Whatever we might think of this strategy, it exemplifies the problem Simondon notices, namely, considering individuals already constituted and ignoring or obscuring their genesis. Regis thus defends composite individuality, but writes nothing of genesis:

> The form of a composite is individual, then, only in the same sense in which its matter is individual, namely, it is just the form (or matter) which the already individual composite happens to have.[61]

The beings in question are "already individual" for Regis, whilst for Simondon their individuation or genesis is precisely the problem. Thus, whilst this asks after the individuality of beings but assumes their existence, Simondon argues that the coming-into-being of beings is their existence, that individuation explains the individuality of an individual.

In defence of proponents of composite individuality, one might argue that they attempt to explain individuality, whilst Simondon attempts to explain the genesis of individuality or individual beings. Individuation, in this way, would have two different meanings: one would be an enunciation of the facet which can be said to make a being singular, whilst the other would be the genesis of individual beings. The Simondonian

[60] Regis, E. Jr. (1976), 165.
[61] Ibid., 164.

response, however, is that there is only one problem and one meaning: what makes a being singular is its continual genesis.

Substantial and accidental genesis

Now, Aristotle does have a conception of both coming-into-being and becoming or continued genesis, most clearly presented in the *Physics* and the *Generation of Animals*.[62] But whilst this is closer to transduction, it is nonetheless incompatible. Aristotle makes the distinction between unqualified coming-to-be (*gignesthai ti*) and qualified coming-to-be (*gignesthai haplôs*), or substantial and accidental genesis.[63] Unqualified genesis describes the coming-to-be of a substance which did not previously exist - Socrates is born, for example - whilst qualified genesis describes a change to an already existing substance - Socrates comes to be healthy from being unhealthy. It is the latter, qualified or accidental genesis, or indeed the very attempt to make a distinction which is incompatible with Simondon's argument. For, whilst Simondon maintains that individuation is discontinuous - an individual has an absolute beginning, or *qua* individual it is not continuous with something prior to it - he also holds that individuation or substantial genesis does not end once a being exists, but continues so long as an individual endures.

Simondon's interest is beings which continue individuating without reaching fulfilment, or equilibrium and stasis. A brick, for example, is not an individual, according to Simondon, but "a partially individuated being" which exists deteriorating until, "after several years or several million years, [it] returns to dust".[64] He writes later in the section, more broadly, that

> the genuine individual only exists for an instant during the technical operation: it exists so long as the taking of form endures. After this operation, what subsists is a result which will degrade [*qui va se dégradant*], not a genuine individual; it is an individuated being rather than a real individual, that is, an individuating individual, an individual individuating itself.[65]

[62] Aristotle (1991).
[63] On this distinction, see Devin Henry's (2019) remarkably clear and edifying text.
[64] Simondon, G. (2013), 48.
[65] Simondon, G. (2013), 61.

A brick, then, does not continue individuating after its unqualified genesis, in Aristotle's terms. It may degrade, or change accidentally, but it does not continue its substantial individuation. Simondon is interested in those beings which are individuating, or whose genesis persists or endures. This might sound strange, to the extent that an unqualified coming-to-be suggests something once and for all. Simondon does criticise hylomorphism for presenting genesis as instantaneous, but primarily the distinction is that individuation - which persists so long as a being exists - is not an accidental but a substantial genesis.

Accidental change to a substance is optional, non-necessary and unusual: something which attaches "neither of necessity nor usually"[66] to a substance or "items which come and go without the destruction of their subjects".[67] Indeed, accidental genesis happens to an underlying substance, adding to it without changing it *qua* substance. Simondon argues, however, that individual beings must continue to individuate and change in order to continue to be or to avoid destruction. Such individuals *may* undergo accidental change (though Simondon does not use these terms) but such individuals must continue to undergo substantial change in order to be. In *Histoire de la notion d'individu*, Simondon thus argues that

> The generation of a substance is abruptly discontinuous; it takes place in an indivisible instant. In that way, Aristotle affirms that indefinite and unlimited *physis*, considered as universal flux, does not exist; there is no flux of substantial forms.[68]

Whilst Simondon must agree that the genesis of a substance is "abruptly discontinuous", he disagrees that "there is no flux of substantial forms". Indeed, Simondon inverts the terms such that substance is genesis, or that substance must continue coming-to-be in order to avoid ceasing-to-be.

This may sound strange and complex, but it is actually rather simple: unlike bricks or technical objects, for example, beings such as living beings change as they convert energy in order to act, grow, perceive and so on. These changes are not accidental -

[66] Aristotle (1991), *Met.* 1025a15.
[67] Porphyry (2003), 12.
[68] Simondon, G. (2013), 382.

possible and optional but not necessary - but rather they are substantial or necessary for the being of individuals. If, for Aristotle, beings come-to-be in an unqualified sense and then come-to-be in a qualified sense until they cease to be, for Simondon, beings are continuously coming-to-be in an unqualified sense. It is not that a new individual appears each moment, nor that the species or form under which an individual could be subsumed changes, rather that the being of beings that transduction describes is one which is substantially genetic. This sense is very clear in Deleuze's expression of the repetition of beings, which may appear self-identical (affording categorial subsumption) but which are properly, or *virtually* differential.[69]

Individuating beings, for Simondon, are substantially genetic. What makes a being individual is not something prior to individuation, matter or form like clay or a mould, nor is it simply result of an individuation: a composite like a brick. Rather, an individual is a genesis, which we will come to see, is a continued conversion of energy. If some of Aristotle's interpreters avoid the classical formulation of the problem of individuation (assigning a principle to *either* the matter *or* the form) and opt for an individuality that is a composite of matter and form, then Simondon asks after the composition or composing. Equally, there is no underlying substance which remains a static seat for changes, rather the individual is itself genetic:

> The genuine principle of individuation is the genesis itself in its operating [*en train de s'opérer*], that is, the system in the process of becoming, during which energy actualises itself. The genuine principle of individuation cannot be sought in what exists before the individuation is produced, nor in what remains after the individuation is accomplished.[70]

Individuality is thus not the composite, but a composition. The problem is not dividing a being into constitutive parts (as proponents of composite individuality hold), but thinking a being as constitut*ed* or compos*ed*, rather than an operation of constitution or composition. In this sense, Simondon re-thinks the principle of individuation as something which is continuous, not the *source* for this being, but the very nature or being of this being.

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[69] Deleuze, G. (1968).
[70] Simondon, G. (2013), 48.

With this we have discussed Simondon's admiration of hylomorphism - as a paradigm with universal range - but we have primarily made a negative determination of transduction in light of Simondon's critique of ancient thought. However, this leads us to following two topics, which deal with the novelty and positivity of transduction. First, we discuss the substantiality or necessity of relation for transductive individuation, and second, the nature of transductive relation as a source of energy.

3. Substantial relation

Thus far we have seen the sense in which Simondon's transduction is an attempt to bridge the gap between particular branches of science - or indeed, regional ontologies - through an operation which can be applied by analogy to beings described by those sciences. We also discussed Simondon's admiration for hylomorphic universality and its paradigmatic method - as an operation which can be applied analogically - and his criticism that it obscures mediation and genesis proper. The attempt to find or produce a universal description for ontogenesis was clear both in the production of an operational analogy for individuation fit for every branch of science, and in the esteem for the universal "force" of hylomorphism.

In this section we discuss the sense in which transduction requires a conception of substantial, rather than accidental relation. We will see the significance of relation emerging in Simondon's philosophy of transduction, to the extent that hylomorphism is criticised for obscuring the mediation crucial for individuation. In this section, then, we discuss the substantial nature of transductive relation according to a brief sketch of twentieth-century developments around a constellation of terms from science and philosophy: milieu, *Umwelt*, *circonstances* and *in-der-Welt-sein*. These moments are both historical conditions for the possibility of Simondon's conception of relation, whilst they also provide a backdrop against which the novelty of transductive relation can be brought into relief. Equally, since Simondon's critical targets (hylomorphism and ancient atomism) are ancient, a discussion of the more recent history of relationality helps both to contextualise and recognise Simondon's own contribution. Indeed, whilst his argument is, to a certain extent, framed as the overturning of ancient conceptions by nineteenth and twentieth-century scientific theories and concepts, Simondon makes

little mention of developments in the conception of relation, of which he was almost certainly aware.

The primary focus of Simondon's critique of relation are thus his frequent targets, hylomorphism and ancient atomism. The reason is that for both, relation is accidental: an individual, in this sense, does not require a relation and remains, *qua* substance, unmodified by any relation it may have. Hylomorphism thus "makes the individual the possible term of a relation"[71] rather than an active limit, which is necessarily or substantially relative, and modified as or with its individuation. Similarly, ancient atomism considers the individual (the atom) a seat for relations which remains unaffected by them:

> In this substantial atomism, collision can modify the state of rest or movement of an atom, but not its proper characteristics, like mass; now if mass varies with speed, a collision can modify the mass of a particle in modifying its speed.[72]

The ancient *atomon* was thus the foundation for all sorts of change, but itself remained unchanged; the collision of atoms cannot alter atoms themselves, but only their relations to one another. Simondon argues, on the contrary, that all individuating beings are modified by their relation to a milieu, including atoms, for which mass is relative to velocity, after Einstein's general theory of relativity.[73]

Simondon clearly demonstrates throughout *L'individuation* that for much contemporary science, relation to a milieu is substantial or necessary for beings. In this way, he provides examples from physics, chemistry, biology and psychology, such as crystallisation, photons and living membranes in order to justify his argument. There is

[71] Simondon, G. (2013), 63.
[72] Simondon, G. (2013), 127.
[73] Simondon's argument is that the concept of an atom has been considerably altered by the theory of relativity, such that atoms can be considered affected by their relation, to the extent that their mass is altered according to velocity. Atoms are thus no longer the unchanged and eternal substances which support accidents:

"Relativistic mechanics profoundly modifies the notion of the individual existence of the physical particle; when it moves at high speed the electron cannot be conceived as one would previously conceive an atom. Since the ancient atomists, the atom was a substantial being. The quantity of matter that it constituted was fixed. The invariance of mass was an aspect of this substantial invariance of the atom…With the electron envisaged by the theory of relativity, the mass of the corpuscle is variable according to velocity, following Lorentz's law". Ibid., 126.

almost no mention, however, of the conceptual development of relation or milieu within the recent philosophical and scientific context. As we will demonstrate, both terms were a significant feature of European philosophy and science in the first half of the twentieth century, and in close proximity if not a direct influence on to Simondon's work. We trace a brief history of the two terms in the European context, attempting to emphasise both Simondon's relative similarity and difference.

Relative terms: *milieu, environment, circonstances, Umwelt*

The significance of relation for philosophy and science was recognised by Georges Canguilhem - one of Simondon's two doctoral supervisors - in his 1953 essay, "Le vivant et son milieu".[74] The text offers a history of the concept "milieu" in natural philosophy and science, emphasising its contemporary significance and providing an overview of what Canguilhem proposes to be the origins and transformations of the term in the European context from the eighteenth to the mid-twentieth century.

The opening passage of the text presents a number of themes that we have discussed already in this chapter, namely, universality, inter-disciplinarity and the problem of individuality, and it is worth quoting at length:

> The notion of milieu is becoming a universal and obligatory mode of grasping the experience and existence of living beings and one could almost speak if its constitution as a category of contemporary thought. But the historical stages of the formation of the concept and the diverse forms of its use, as well as the successive reversals of the relationship in which it is one of the terms - in geography, biology, psychology, technology, economic and social history - all this has been difficult, until now, to perceive in a synthetic unity. For this reason, philosophy must take the initiative in synoptically investigating the meaning and value of this concept. By initiative, we do not mean what appears to be an initiative but only consists in reflecting on the sequence of scientific explorations so as to compare their appearance and results. Rather, through a critical comparison of several approaches, we mean, if possible, to bring to light their

[74] Canguilhem, G. (2015 [2008]), 165-197, [98-121]. Whilst Simondon does not make specific reference to the text, though the collection in which it was published is included in the bibliography for Du Mode.

> common point of departure and to postulate their fecundity for a philosophy of nature centred relative to the problem of individuality.[75]

According to Canguilhem, then, the notion of milieu is "becoming a universal mode" for conceptualising living beings, and the contemporary scientific moment makes possible a synoptic or inter-scientific work which may be undertaken within the discipline of philosophy. In turn, the synopsis of these various branches of science has the capacity to produce a general notion for "a philosophy of nature centred relative to the problem of individuality".

This appears quite similar to Simondon's own search for a universal notion, fertile for a philosophy of nature centred on the individual. Indeed, we have discussed Simondon's conception of cybernetic analogy, whereby different branches of knowledge are brought together with a single operational term, and also the sense in which philosophy must take synoptic initiative relative to particular branches of science. What is different for Simondon, however, is that although an individuating being is always in relation to a milieu, as we will discuss, he emphasises the nature of relation over that of milieux. Equally, whilst Canguilhem limits the scope of the term to living beings, Simondon seeks a term without vitalist limitation, which is instead universal for physical, vital and psychic individuations.

The key conceptual transition in Canguilhem's text is that from a conception of milieu as a medium for the action of force to one as a relation of energy and life. The historical discussion thus begins with the French translation of Newton's "medium" for force (fluid or ether, for example) as "milieu" in Diderot and d'Alembert's *Encyclopédie*. A milieu, in this sense, is an intermediary (literally, *mi* "mid" + *lieu* "place") through which bodies may move or relate at a distance. d'Alembert thus writes in the entry for milieu in the *Encyclopédie* that it is "a material space across which a body passes in its movement".[76] For Newtonian natural philosophy, the ethereal medium (or milieu) played a significant role in the explanation of action at a distance as the intermediary which could transmit the effect of force.

[75] Ibid., 165 [98] (translation modified).
[76] Alambert, J. R. (2017), 10: 509.

This dynamical sense of a mechanical milieu seems to express something of what Simondon is attempting to get away from, as it assumes a separation of bodies or terms which are only accidentally brought into relation. Bodies are able to relate through a medium, but this relation is not necessary for their existence. Canguilhem is also primarily interested in a later, substantial conception, namely, milieu as a requirement for life. In this sense, a milieu is not a mere medium for the transmission of force but the source of climatic and energetic conditions necessary for sustaining and replicating life.

Despite its dynamical origins, however, Canguilhem maintains that milieu is superior to *circonstances*, *Umwelt* or environment. Indeed, he does not affirm the dynamical sense of a medium, nor Comte's physiological conception. But he maintains, nonetheless, that milieu is superior to terms based on images of circularity - like Lamarck's "circonstances", Étienne Geoffroy Saint-Hilaire's "milieu ambient", but also the later environment or *Umwelt*.[77] He reasons that these terms depend on a central privileged position, whilst

> milieu does not evoke any relation except that of a position endlessly negated by exteriority. The now refers to the before; the here refers to its beyond, and thus always and ceaselessly. The milieu is truly a pure system of relations without supports.[78]

Thus, the relation associated with the term milieu does not have a fixed centre but involves a becoming relation which negates what would be a centre, both temporally and spatially, or better, topologically. Semantically this is close to Simondon's critique of accidental relation, or the privileging of beings over relation. Lexically, however, it is at least a little strange, since *mi-lieu* (*mid-place*) clearly invokes its dynamical heritage as the medium which transmits the action of force from one term to another. This need not undermine a critique of *semantic* centredness in environmental terms, but it undermines Canguilhem's etymological critique of *circonstances* and *ambiance*: if the meaning of milieu changed, then the meaning of other terms may also change. Above all, this may be an example of the combination of terminological continuity and semantic

[77] Their etymologies also attest to circular and centripetal meaning: ambient, from Latin *ambient* 'going round', from *ambire*; and circumstance, from Latin *circumstantia*, from *circumstare* 'encircle, encompass', from *circum-* 'around' + *stare* 'stand'.
[78] Canguilhem, G. (2015 [2008]), 172, [103].

discontinuity, a contingency of terms relative to meaning and perhaps an advantage of historical semantics over etymology.

Whatever Canguilhem's position, however, in *L'individuation* milieu is always relative and subordinate to a centre of individuation. Simondon does not thematise either milieu as a term or its history, but neither does he shy away from concerns for a unity of individuation expressed as a "centre" or as "internally resonant". To a certain degree this demonstrates the extent to which Simondon's focus is on beings in their individuating, rather than a wider ecology, but it also points to an underestimation of milieux in their own right. Indeed, milieu in *L'individuation* tends to be rather indeterminate, that which an individual relates to as a source for energy, information or sensation, but without specific or indeed individual determination. Simondon does not reflect on the sense in which specific individuating beings must inhabit specific milieux in order to live and survive, that an individuating being requires a milieu with which it is compatible. Rather, the milieu which individuation must relate to is left precisely unspecified and indeterminate.

This may appear to result, in part at least, from Simondon's considerations of universality. However, that specific beings require specific milieux or environmental conditions is a universal statement like any other. This is clearly distinct from one significant biological sense of the term (which begins with Comte according to Canguilhem), whereby a specific organism requires a specific corresponding milieu for its life and survival: photosynthesising plants cannot live in milieux without light, for example.

In *L'individuation* the milieu is not considered a finely balanced, changeable and changing network of beings interacting with one another and with geological, meteorological and chemical conditions. Nor, indeed, does Simondon properly pursue the sense in which a milieu for an individual may in fact be a homeostatic individuating being in its own right.[79] In this light, too, trans-individuation is something of a missed opportunity to the extent that it is presented as an almost entirely human affair, rather than an inter-species ecology.

[79] In this respect, Simondon's work does not anticipate the Gaia hypothesis, which is not to say that the two are incompatible, however.

Simondon's emphasis on individuating beings-in-relation over the nature of the milieu they relate to may tell us something about the historical-conceptual moment in which Simondon was writing, however. In this regard, "Le vivant et son milieu" is helpful as it emphasises inversions in the order of productive priority between living being and milieu in the historical period and conceptions that it traces. Simondon's individual-centred position thus appears, in this way, in keeping with a tendency which Canguilhem traces in the early twentieth century.

The semantic inversion, in this respect, is the distinction between a milieu that has a productive role in selecting or shaping beings and species on the one hand, and a milieu which is produced by living beings on the other. Lamarck and Darwin follow the former tendency.[80] For both, a milieu can alter living beings whilst each is relatively autonomous from the other, life produces variation whilst environmental factors work negatively on that production by reformation or selection. For Lamarck, the milieu alters living beings through the intermediary of need, such that changes in "circumstances" may lead to changes in need, including the use and non-use of organs. In turn, the hereditary mechanism can then lead to morphological or organological loss or novelty. The difference for Darwin is that there are two mechanisms, variation and selection; whilst the latter can result from the milieu, he primarily emphasises the result of relations between organisms for selection.

The "inversion" of this tendency, according to Canguilhem, comes with the work of Jacob von Uexküll, for whom the milieu or *Umwelt* (literally, *surrounding-world*) is constituted by the organism. Milieu and organism are thus not autonomous, accidentally relative terms in this conception, and temporality is diachronic or limited to individual beings, rather than evolutionary or phylogenetic. An *Umwelt*, for Uexküll, is made possible by the specific capacities of an organism, and specifically different capacities produce specifically different *Umwelten*. In this way, though Canguilhem does not mention it, Uexküll's position is decidedly transcendental: the capacities of an organism are the conditions for the possibility of its milieu. This inversion is thus like Kant's, so called, Copernican revolution, whereby objects of experience are no longer grasped as existing in-themselves or irrespective of relation to a being, but are instead

[80] Canguilhem, G. (2015 [2008]).

made possible by the capacities of human beings. Objects, for Kant, depend on a transcendental synthesis.[81]

Simondon's conception of the milieu relative to an individuation falls broadly on this side of the division because his conception is so focussed on the individual, but also because his conception of individuation does not include species evolution. Indeed, he often describes transduction as "ontogenesis", which may indeed be a play on "ontology of becoming" (an *onto-genesis*), but it should also be read as "not-phylogenetic", since he never properly thinks the problem of evolution, as we will discuss in the following chapter.

Although Simondon's relation to milieu is not phylogenetic like Lamarck's or Darwin's conceptions, however, neither is it transcendental in the same sense as Uexküll's. Indeed, whilst for Uexküll an *Umwelt* is produced by perceptive capacities, for Simondon the milieu is primarily a source of energy (or indeed being) for beings. If Simondon's conception can be considered transcendental, it is an inversion of Uexküll's: the milieu is the condition for the possibility of individuation as a source of energy required for maintaining being. For Uexküll, an organism's relation to a milieu is grasped in terms of the transcendental productive capacity of an organism and the resulting perceptual milieu. In this sense, energy is presented as an orientating factor within a perceptual *Umwelt* - as food towards which a being comports itself, for example - but Uexküll does go beyond the perceptive relation to consider the energetic relation to milieu as a fundamental source for the sustenance of life or being. In this sense, in Simondon's text, whilst physical individuation might appear ontologically meagre in comparison to that of living beings,[82] it may be crucial in affording a non-perceptive relation of energetic sustenance, which is nonetheless universal to physical and living individuations. A crystallisation is necessarily relative to a milieu as a source of energy, but it has no capacity for reaction or behaviour, and thus serves to emphasise a fundamental, yet non-perceptive relation also shared by organisms.

[81] Kant, I. (1998).
[82] Physical individuation properly includes only crystallisations and, in some editions of the text, also quanta, whilst examples of living beings are more numerous and complex (include various different scales - such as the psychic, collective and technical - and various forms of unity).

This is not to say that an *Umwelt* made possible by the capacities of an organism are any less necessary than a relation supplying energy to sustain being or to continue individuating, nor, indeed, that perception is any less energetic. Rather, Uexküll's conception of the productive relation to an *Umwelt* is limited to perception in such a way that it excludes the provision of energetic sustenance such as photosynthesis or biosynthesis. Uexküll is quite convincing in his demonstration of the transcendental capacities that make possible environmental factors, which are indeed necessary for life (bees, for example, do not perceive closed buds but only blossoming flowers which they require for pollen),[83] but for him the relation to environment is always one of perception. Such perceptive relations are energetic (visible light, after all, is electromagnetic radiation) and fundamental, serving actions which involve the sustenance of life - finding nourishment or fleeing predators, for example. However, the perceptive relation to an *Umwelt* does not entail the basic sustenance of life, for Uexküll, but only some of the actions which make it possible.

In this respect, Simondon's milieu is quite different from Uexküll's *Umwelt*. Indeed, whilst Simondon goes on to discuss milieux of perception, both in *L'individuation* (in "L'individuation psychique")[84] and later in *Imagination et invention*,[85] he pays particular attention to the fundamental energetic relation required for the sustenance of individuating beings. In order to continue individuating or to sustain existence, energy is required: a crystal requires energy from its supersaturated liquid milieu as most plants require sunlight and animals require glucose.

We will discuss the fundamental nature of energy in more detail in a moment, but it may be useful to recap what we have discussed thus far regarding relation. We first saw the sense in which a milieu is not accidental or optional for an individuating being, but is rather substantial or necessary, for Simondon. A similar distinction appeared in Canguilhem's text in the historical and technical shift from the dynamical conception of milieu as a medium for bodies and action at a distance, and physiological and biological

[83] Uexküll, J. (2010), 84. Uexküll provides a number of diagrams for animal perception, with different depictions of the same image (for the human observer, at least) in order to compare the perceptive capacities of different species, and which serve well to express the sense the Umwelt is ultimately aesthetic, for Uexküll.
[84] Simondon, G. (2013), 229-284.
[85] Simondon, G. (2014).

conceptions, in which living beings are inconceivable without a milieu. Milieux, in Simondon's conception of relation, were considered indeterminate or lacking specificity and thus unlike Lamarck's or Darwin's evolutionary considerations of a mechanism for producing harmony (from disharmony) between specific beings and their environments. Finally, we discussed the extent to which Simondon emphasises an energetic relation required for the sustenance of individuation or being as well as for perception. If Simondon's milieu is indeterminate, lacking the specificities which particular beings require, like ranges of temperature, geographical and geological conditions, other living beings and populations thereof, it may be determined as energetic. In this sense, Simondon's milieux are not properly habitats, but rather sources of energy. As we will discuss in the final section, relation to a milieu is transductive, that is, it is a conversion of energy, whether for fundamental ontological sustenance or for perception.

Dasein's substantial relation: *Being-in*

Before discussing the role of energy in Simondon's philosophy in more detail, however, we ought first to reflect on another early-twentieth-century conception of substantial relation to environment (or *Umwelt*), which is absent from Canguilhem's text and apparently non-scientific: Dasein's Being-in-the-world (*in-der-Welt-sein*).

Simondon does not cite Heidegger in *L'individuation* or *Du Mode*, though he had studied his work with Jean Wahl earlier in the 1950's. We are thus not pursuing an evidenced claim about an influence on Simondon's work, even if Being-in-the-world is a significant part of the backdrop to the philosophical context in France in the 1950s. Rather, discussion of the similarities and differences between the two conceptions of relation will help both to determine Simondon's conception and his conceptual novelty, but also make possible a criticism of Heidegger's text.

Both Heidegger and Simondon articulate a relation which is necessary for being, that is, not optional or accidental. Thus, Dasein's "Being-in" [*In-sein*] is not the same as an entity "in" a container, like water in a glass or a jumper in a wardrobe, for example. It is not that it is impossible for Dasein to be grasped or to grasp itself as if it were a separate entity in another entity called world, only this entails a fundamental misunderstanding which obscures the being of Dasein. Indeed, Dasein does not just happen to be in a

world which it might just as well exist without: Being-in is not an accident, an option or a possibility for Dasein. Being-in is necessary and fundamental for Dasein's very being:

> Being-in is not a 'property' which Dasein sometimes has and sometimes does not have, and *without* which it could *be* just as well as it could with it. It is not the case that man 'is' and then has, by way of an extra, a relationship-of-Being towards the world - a world with which he provides himself occasionally. Dasein is never 'proximally' an entity which is, so to speak, free from Being-in, but which sometimes has the inclination to take up a 'relationship' towards the world. Taking up relationships towards the world is possible *because* Dasein, as Being-in-the-world, is as it is.[86]

Being-in is thus not temporary, occasional or indeed accidental for Dasein; it is not a mere possibility for Dasein. Dasein must be in a world, Being-in is a part of what it means to be Dasein. Dasein has the possibility for multiple different relationships to the world (as we see in latter two sentences above). These relationships (of care) are indeed various, according to Heidegger, and include those like "producing something, attending to something and looking after it, making something",[87] for example. Such multiple different relations, however, are all made possible by Being-in, which is more fundamental and indeed, more general.

Simondon's expression of relation is similar to the extent that it is not accidental but necessary. He criticises the sense in which an individual is grasped as a term which may or may not be relative, which, as a being can be grasped without including its relation to a milieu. This explains his frequent comment that the individual *is* a relation: the individual is a process of relating, both drawing energy from but also differentiating itself from a milieu. Relation to a milieu is not an accident of an individual or substance, which may or may not be relative; relation is necessary, not optional.

Both offer prepositional precisions or even redefinitions in order to express this necessary relation: Heidegger with Being-*in* and Simondon relative *to*. Indeed, Heidegger has to explain to the reader that Dasein is not *in* the world as a thing in a vessel - as a coin is *in* a cup - but that its being partly depends upon the world which it is

[86] Heidegger, M. (1962), 84.
[87] Ibid., 83.

in. Simondon equally explains that an individual is not relative *to* a milieu as a separate being which may or may not relate to that milieu - a brick relative to a mould, or to other bricks in a wall - but instead its relation *to* is the being of individuality, it is always as such. For Heidegger as for Simondon, relation is not merely an accident of a being, it is constitutive of its very being.

It might be noted, with examples like coins and bricks, that Heidegger's Being-in and Simondon's relation to are reserved for certain kinds of beings. We might wonder whether beings like coins or bricks could ever be without being in or relative to something. Heidegger goes so far as to argue that to say "'the chair "touches" the wall'" is strictly speaking incorrect as "this would presuppose the wall is the sort of thing 'for' which the chair would be *encounterable*".[88] Only certain beings have encounters in a world, or indeed have a world at all. Simondon, as we have already seen, argues that a brick is not an individual, and argues much the same for the crystalised crystal: it *was* an individuating being in relation to a milieu, but now it is at thermodynamic equilibrium, neither individuating nor in a transductive relation.

Both distinguish those kinds of beings which are and are not relative in this necessary sense, but each give different reasons, which in turn specify different beings. Like Uexküll, Heidegger remains within the remit of perception. Thus, when he comes to discuss the meaning of Being-in-the-world in more detail - in *The fundamental concepts of metaphysics: world, finitude*, *solitude*[89] - he argues that living beings have a world whilst non-living beings do not. Further, living beings are distinguished according to the nature of their worlds, such that "animals" are poor in world, whilst humans are richer in world and world-forming. He thus argues that a stone is world-less because it has no access to other beings, but evidence given is primarily based on the common-sense proposition that a stone is not self-moved or self-orientated relative to its environment or other beings, whilst animals and plants are.[90] With direct reference to Uexküll,[91]

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[88] Ibid., 81.
[89] Heidegger, M. (1995a).
[90] For example: "The stone lies on the path. If we throw it into the meadow then it will lie wherever it falls. We can cast it into a ditch filled with water. It sinks and ends up lying on the bottom. In each case according to circumstance the stone crops up here or there, amongst and amidst a host of other things, but always in such a way that everything present around it remains essentially *inaccessible* to the stone itself." Ibid., 197.
[91] The diagrams in Uexküll's text give image impressions of visual Umwelten for different species, and they are ordered according to increasing definition. There is nothing additional given in the image of the

Heidegger argues that whilst animals and plants have a world, they do not have access to beings, they are "*Related to other things*-although *these other things are not manifest as beings*".[92] Thus, animals and plants are poor or deprived of world, but not without world, in the way that a stone is.

If Heidegger has a humanist tendency, he also demonstrates a vitalist one. At various moments in the text he expresses satisfaction at what he takes to be the increasing autonomy of biology through its demarcation of what is proper to life alone, "attempting to defend itself against the tyranny of physics and chemistry".[93] This is quite unlike Simondon's text, which attempts to fold physics, chemistry and biology into the same universal transductive description of individuation. Heidegger may be correct according to his metric, since a stone or a crystallisation surely does not have an Umwelt of perception-action or access to other beings. But making an ontological claim only according to whether something has an Umwelt and the relative complexity thereof is a significant oversight. Indeed, we could defend the lack of energy or nourishment in Uexküll's conception of the Umwelt by arguing simply that his interest is worlds of perception and action and not the sustaining relation to milieu which Simondon's transduction describes (as well as the former). When it comes to Heidegger, however, it appears simply as an underestimation, particularly when it comes to the being-in or the energetic relation that beings require.

What Heidegger seems to forget, perhaps in his hostility to natural science, is the role which energy plays in the relation of a being to the world. In *Being and Time* he argues that the Umwelt is presupposed by biology though its meaning is lost on the discipline, because it is "conceived beforehand as a structure of Dasein".[94] Thus, the Umwelt may only be grasped by philosophy, and properly only *after* Heidegger's text, which is apparently the first to do so. There is a significant irony, however, in Heidegger's

perception of a bee, for example, only a less defined or simplified image of the human visual image. There is thus a certain priority given to human perception, with images of village streets, for example, increasing in complexity up to human sight. There is no mention of the capacity of bees to perceive ultraviolet radiation, or the comparatively lacklustre human capacity to hear or to smell. The diagrams serve as a good indication of the hierarchy of complexity in perception that Uexküll puts forward, and the prioritisation of sight.

[92] Heidegger, M. (1995a), 254 [italics original].

[93] Ibid., 188.

[94] "Umwelt is a structure which even biology as a positive science can never define, but must presuppose and constantly employ." Ibid., 84.

analysis of Being-in-the-world and even more so Being-in, to the extent that his interest in the world and in-ness appears to cause him to ignore something fundamental about Being in those terms. Indeed, Dasein may necessarily be *in* a world (the fundamental structure of which may be expressed as Being-in); but Dasein must have another relation to the world to the extent that it requires energy. In *Being and Time* Heidegger does not reflect on the necessity of Dasein's energetic replenishment (Dasein does not seem to eat, in *Being and Time*), which is required to maintain its being and avoid death. Without energy Dasein ceases to exist, there would be nothing without nourishment. There is similar neglect of energy in *The fundamental concepts of metaphysics*, in which there are a handful of mentions of "nourishment", but which, moreover, only concern perceptive comportment.[95] In this sense, nourishment merely describes something that an organism is orientated towards, in the same way that it is orientated away from predators in its Umwelt. There is no mention of the fact that nourishment is a source of energy necessary to sustain life, which is precisely sourced through relation to a world, and without which sensation and perception - conditions for a world as Uexküll and Heidegger understand it - would be impossible.

Simondon's articulation of conversions of energy as necessary for individuation or being thus offers a significant ontological insight which is almost totally shrouded in Heidegger's early texts. Relation to a milieu as a source of energy required for the maintenance of being also offers a means to extent the transductive ontology to inanimate beings, such as crystallisations. Exemplifying the non-living with a stone serves to ignore the two-hundred-year-old analogy between crystal formation and life.[96] Had Heidegger discussed crystallisation, he may have noticed something fundamental about Being-in which is universal to the physico-chemical as to the living: the conversion of energy.

Before we discuss energy, we might briefly note the sense in which we refer to transduction or the energetic relation it describes as "fundamental"; that is, as a description which grounds the ontology of generation, or indeed transduction as

[95] See, for example: Ibid., 198, 241, 242. Heidegger asks a penetrating question - "What does the animal relate to, and what sort of relationship does it have to whatever it seeks as nourishment, seizes as prey, or attacks as hostile?" - but responds with a behaviouristic analysis, with no mention of the energy conversion required for the being of living beings. Ibid., 200.
[96] Jacob, F. (1970), 324 [303].

Simondon understands it. In this sense, the energetic relation which we are discussing comes first with regards to other aspects of Simondon's text. Simondon *rests* his own philosophy on scientific description, which serves as the ground on which his ontological description can be built. Thus, Contrary to Heidegger's "fundamental ontology" which may serve as a ground for the natural or empirical sciences, scientific thought comes first in Simondon's philosophy, and it is a part of what makes his ontology possible. Miguel de Beistegui similarly finds such a reversal of Heidegger's position in Deleuze's philosophy, arguing that science is a requirement for ontology today.[97] But whilst de Beistegui, following Deleuze, attempts to think being *qua* being through a univocal and differential ontology, we contend that Simondon's position is more particular, pertaining only to negentropic beings. Energetic relation, or transduction is thus not *the* fundamental description for ontology, nor indeed does it provide *the* grounding description for genesis. As we will discuss later in this chapter, Simondon's ontological description is limited to negentropic beings and negentropic genesis, and thus his conception of transduction cannot hope to serve as the ultimate or universal ground. Equally, although Simondon's work is sometimes considered all-encompassing or "encyclopaedic" in aim, if not achievement, it is worth noting that he does not discuss or include other fundamental aspects of being, such as culture, history, kinship or love, for example. In this regard, we maintain that Simondon's articulation of transduction serves as *a* ground or fundamental description that must coexist in a constellation amongst others.

Emanuele Coccia has recently written on the Being-in of plant life, criticising Heidegger's prioritisation of humans over animals and plants whilst remaining deeply indebted to his conception of Being-in-the-world, nonetheless.[98] Like Alessandra Viola and Stefano Mancuso's ostensibly less philosophical but ultimately more convincing *Brilliant Green,*[99] Coccia's text is deserving of praise for its emphasis on plant life. However, whilst he successfully criticises Heidegger for his overemphasis on human life, he effectively makes the same mistake as the former in underestimating the significance of energy for Being-in-the-world. Indeed, whilst Coccia notes plants'

[97] Though it might be noted that whilst de Besitegui also proposes an ontology of the "*Abgrund*", we contend that this underestimates the constitutional or fundamental role of scientific thinking.
[98] Coccia is rather quick in this respect, asserting that "Heidegger…along with the rest of twentieth-century philosophy" asks the meaning of being in the world "of humankind". Coccia, E. (2019), 21.
[99] Viola, A. and Mancuso, S. (2015).

requirement of energy from sunlight, he argues that: "The being in the world of plants resides in their capacity to (re-)create atmosphere". That is, their fundamental relation to the world is to produce oxygen from carbon dioxide, rather than photosynthesising to maintain their own being and produce biomass which, directly or indirectly, maintains the life of almost all other living beings.

Side-lining energy allows for "breath", Coccia's central concept, to be presented as the catchall process for being-in-the-world. Breath is thus not only respiration, for Coccia, but a dizzying variety of other processes as well: "Breath is not only air in motion: it is lightning, unveiling, means of revelation…the originary essence of what the Greeks called *logos,* language, reason", it is "intellection…the idea, the concept", "the first name of being in the world", "[s]ight is breath", "[e]verything in the realm of the living is the articulation of breath: from perception to digestion, from thought to pleasure, from speech to locomotion".[100] Coccia's fidelity to the concept of breath eventually leads to its identification with the transformation of energy in photosynthesis. Plants would thus

> make the sun live on Earth: they transform the Sun's breath – its energy, its light, its rays – into the very bodies that inhabit the planet, they make of the living flesh of all terrestrial organs a solar matter.[101]

Coccia comes a little closer than Heidegger to recognising the fundamental role of energy for being-in, but he obscures it with his airy rhetoric. Instead of a careful discussion of the generality and complexities of the conversion of energy, in identifying energy with his vague notion of breath Coccia serves to conceal more than he illuminates.

4. Energy

In discussing Simondon's conception of relationality, we have been led ineluctably to a discussion of energy. To discuss one is to discuss the other, and they can only be held apart artificially when discussing Simondon's work. Separating the two, however, has hopefully served to demonstrate more clearly Simondon's criticism of accidental relation, or that which is a possibility, but not a condition of possibility for being.

[100] Coccia, E. (2019), 52; 55.
[101] Coccia, E. (2019), 87.

Equally, we noticed that the temporality of relation is individual or ontogenetic, for Simondon's ontology, rather than specific of phylogenetic: individuation relative to a milieu is not considered in terms of variation and selection. Finally, in beginning to recognise the necessary unity of relationality and energy for Simondon's conception of transduction, we were able to detect something of a fundamental blind spot in Heidegger's relational ontology. Being-in is considered only according to a capacity to have a world, for perception and action, self-movement within a world and for world-making. Heidegger greatly underestimates the necessity for an energetic relation to a milieu or world for the life or being of beings.

For Simondon, energy fulfils and extends the substantial nature of relation involved in transductive individuation. Transduction is necessarily energetic - it is a conversion of energy - and transductive individuation requires energy in order for an individuating being to continue to be. But energy is also particularly significant for the other theme of universality and specificity, which we discussed earlier with regards to cybernetic analogy. First, the almost universal acceptance of energy across branches of natural science is a condition for the possibility of the general applicability of transduction - significantly helping to fulfil Simondon's aim for a "single fundamental type of operation". Second, the energetic description of negentropy affords a specification of the beings to which transductive individuation applies. Energetic description is effectively universal to natural science, included in all of its branches, whilst negentropy affords an ontological specification of transductive individuals. We will discuss these two aspects in what follows.

The universality of energy conversion

It is worth returning now to the definitions of a transducer and allagmatics which we introduced at the beginning of this chapter. A transducer, according to the first section of Graf's definition, is:

> A device, component, machine, system, or combination of these that converts energy from one form to another. The energy may be in any form, such as electrical, mechanical, acoustic, etc.[102]

[102] Graf, R. F. (1999), 792.

In this sense, a transducer transforms or converts energy from one "form" to another. Clearly, this does not precisely equate Simondon's transductive individuation, since such beings are not simply transducers - fixed devices which convert an input energy into another form which then becomes an output. Indeed, a transductive individuating being *is* itself a transduction: individuation shifts the meaning from device to event.

The definition above nonetheless tells us something significant about Simondon's transduction. A transducer in the above passage is universal to conversions of energy ("the energy may be in any form"); it is a device which converts energy from one form to another, irrespective of the actual form(s) of energy. This universality of energetic conversion is reflected in Simondon's compressed definition: "allagmatics (a theory of conversions)". Equally, if we remember that allagmatics was an attempt to find an operation which could unify branches of science, perhaps with "one single fundamental type of operation", then the conversion between any form of energy might be a good candidate. This does not mean flattening physics, chemistry and biology into a general energetics, but rather, it entails the description of an operation universal to the branches of science in question, which rests on the shared theory of energetic conversion.

Part of the work of universality was already completed by theorists and experimentalists in the natural sciences by the time of Simondon's writing *L'individuation*. Energy is widely accepted across branches of natural science and is fundamental, if not to every branch, at least to those with which *L'individuation* engages - physics, chemistry, physiology, biology and (Gestalt) psychology. The aim for a "Cybernetic induction" or an operational analogy which could unify branches of science, which we discussed at the beginning of this chapter, was thus in some sense already historically underwritten by the theory of thermodynamics, expressed in its three laws and articulated across the branches of natural science. This is not to say that interpretations of the laws of thermodynamics and their expressions in energetic processes were simply agreed upon within or between disciplines. Rather, the conversion of energy was (and remains) widely agreed upon and fundamental for physics, chemistry and biology. It is on this empirical-theoretical foundation, then, that Simondon builds his own conception of transduction, or "theory of conversions".

As we have mentioned already, transduction is common to physics, chemistry and biology, equally applicable both physical and vital individuations. In this sense, it appears to be an attempt to avoid a vitalism such as that Simondon attributes to Bergson,[103] and instead to find a way of describing individuation or singular genesis which is not opposed to matter or physics, or indeed, limited to life. The broad, even universal acceptance of energy or thermodynamic description across branches of science is crucial for Simondon's own argument for transductive generality. Indeed, the transdisciplinary acceptance of energy is a historical condition of possibility for Simondon's argument.

In order to explore and defend this claim for energetic universality across the sciences, it is worth briefly discussing François Jacob's *Logic of life*, which offers an edifying historical sketch of the acceptance of energy in the life sciences.[104] Particularly significant for our purposes is Jacob's claim that the extension of thermodynamics to the study of life was instrumental in the decline of organic chemistry and physiology and the birth of biology, a new discipline for which descriptions of conversions of energy are fundamental and shared with the disciplines of physics and chemistry.

Jacob tells the story according to the cessation of a specifically "vital force" (*Lebenskraft*) and its replacement by energy. *Lebenskraft* was employed in the eighteenth and nineteenth centuries, according to Jacob, in order to explain the chemical synthesis of organic compounds and maintain the irreducibility of vital transformations to inorganic or mineral chemistry. Whilst "living beings were formed of the universal chemical elements that compose all matter", it was recognised that their transformation of food-stuffs produce compounds very different to those of inorganic chemistry, which, unlike inorganic compounds, remained un-synthesisable in the laboratory.[105]

The principle of *Lebenskraft* was thus employed to explain life's inimitable synthetic capacity:

> Unable to link together carbon and hydrogen, chemists considered the barrier between organic and mineral to be insuperable. Only vital force could overcome

[103] Simondon, G. (2012) 215, 321 [168, 242].
[104] Jacob, F. (1970).
[105] Ibid., 107 [93].

> the counterflow of the forces acting on matter. According to Liebig, the organic chemist was not even under the obligation to verify the results of organic structural analysis by synthesis.[106]

As hydrocarbons remained impossible to synthesise in a laboratory, many chemists held that this was only possible by the action of *Lebenskraft,* a force specific to living beings which could overcome the counter-force of inorganic compounds. Ultimately, however, technical advances in laboratory chemistry in the mid-nineteenth century made possible the synthesis of organic compounds from inorganic elements, and so withdrew the possibility for chemical difference between the non-living and the living, and so too the need for a *Lebenskraft* to explain that difference.

If *Lebenskraft* declined as a means to delineate vital difference in the mid-nineteenth century, according to Jacob, it was the thermodynamic expression of energy which positively unified the theorisation of physico-chemical and vital processes. In this way, he lays emphasis in particular on the conservation of energy (expressed in the first law of thermodynamics) as the factor which united physical, chemical and living conversions in the nineteenth century:

> With the concept of energy and that of conservation, which united the different forms of work, all the activities of an organism could be derived from its metabolism. Everything that a living being could accomplish in terms of movement, electricity, light or noise became the result of the conversion of chemical energy released by the combustion of foodstuffs.[107]

"Work" is the crucial term in this passage, describing the use of available energy for processes such as growth, movement and sensation. In order to do work, available energy in an environment or milieu is converted from one form to another by a living being. Thus, for example, photosynthesis involves the conversion of energy from electromagnetic to chemical energy. Energy thus broadly replaced *Lebenskraft* in explanations of inorganic chemical synthesis, but unlike the latter, energy is not specific to the sciences of life, but general to physics, chemistry and biology.

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[106] Ibid.
[107] Ibid., 212 [194].

It ought to be noted that whilst Jacob consistently refers to the conservation of energy as the crucial factor in this historical conceptual shift, it is less the quantitative constancy of energy than the unified theoretical description which is pivotal. What is decisive is that the theory of energy and its conversion is common to particular branches of science and their particular beings: "The principle of conservation of energy turns each change in nature into a conversion of energy".[108] The conversion of energy between so-called physical, chemical or vital forms is grasped in the same way under the same principles, and a principle specific to life (like *Lebenskraft*) is no longer necessary or possible. That energy is neither created nor destroyed, but remains constant, is thus not the operative factor in the historical shift (particularly since force was long considered conserved in mechanical descriptions).[109] Instead, Jacob's emphasis is the increasing disciplinary generality of energy.

The disciplinary universality of energy conversion and the consequent decline of vitalism is a central theme of Jacob's history of the life sciences. Indeed, he goes so far as to argue that thermodynamics and the related energetic theories of statistical mechanics and cybernetics each produced descriptions which significantly, if not entirely diminished the claim for the uniqueness of life. He thus writes in the conclusion to his text, that

> To recognise the unity of physical and chemical processes at the molecular level is to recognise that vitalism no longer serves any function. In fact, since the appearance of thermodynamics, the operational value of the concept of life has continually dwindled and its power of abstraction declined. One no longer examines life today, one no longer attempt to define it. Instead, we attempt to analyse living systems in their structure, their functions and their history.[110]

At the molecular level, then, living processes have been regarded as increasingly reducible to physical and chemical processes, such that biology does not study a proper and particular being. Of course, many biologists may disagree with the assertion that they do not attempt to define or study life, but very few, if any, would disagree with the

[108] Ibid., 211 [193].
[109] See, for example, Elkana, Y. (1974), 29, or Harman, P. M. (1982), 36-9.
[110] Jacob, F. (1970) 320 [299] (translation modified).

claim that life is necessarily energetic and shares its conception of energy with physics and chemistry.

Jacob points towards something very significant for our discussion of Simondon's conception of transduction, namely, that the history of the theoretical description of energy, its forms and conversions, is one of increasing generality for the disciplines of physics, chemistry and biology. The decline of *Lebenskraft* and its replacement by a description shared by physics and chemistry goes some way to explaining the sense in which the theory of energy was a condition of possibility for Simondon's aim for a single operation, applicable across the sciences. Jacob's text offers us a sketch of the development of energy for the study of life as an increasingly general "theory of conversions", which provided an empirical and theoretical justification for Simondon's argument.

We may query the implication in Jacob's thesis, however, that the generalisation of energy involved a reduction of the life sciences to physics. Instead, we may contend that energy is not proper to any branch of science. The initial theorisation of energy, or at least its conservation, may have been within physics,[111] but this does not mean that energy is physical any more than biological, chemical, psychological or neurological. Energy is precisely converted between the beings expressed by regional ontologies, from the non-living to the living and back. Just as there is no need to for a special principle to explain the transition from the inanimate to the living, there may be no need to assign energy as proper to any discipline. In this way, the science of energy would have already gone some way to achieving Simondon's allagmatic aim of a universal transdisciplinary description of conversion. Theoretically and empirically, the general extension of the science of energy in the nineteenth and twentieth century laid the foundations for the universality of Simondon's transductive ontology.

The conversion of energy provides a theoretical foundation for Simondon's attempt to find a "single fundamental operation", and there is no doubt that it is pivotal for the project in *L'individuation*. He argues, for example, that hylomorphism mistakenly leaves energy out of individuation, phrases relation as "The energetic foundation of

[111] Though it is also worth remembering that Helmholtz' landmark 1847 paper on conservation - *Über die Erhaltung der Kraft* - was the first he had written outside of physiology.

individuation: individual milieu",[112] and gives metastability a central and necessary role in the being of individuation. In this way, energy may even be said to take the place of being in Simondon's "ontology". Whilst he systematically refers to "beings", to ontology and ontogenesis, he does not discuss the meaning of the word "being". The meaning of energy, transduction, potential energy, metastability and homeostasis, on the contrary, are significant and regular topics in *L'individuation* and *Du Mode.*

What we have tried to demonstrate, above all, in our discussion of Jacob's text is that there was a universal "theory of conversions" long before Simondon began to work on *L'individuation*, even if he does not fully acknowledge it. This does not detract from Simondon's contribution,[113] but should serve to emphasise the sense in which his position rests on a natural scientific description, even if he makes significant developments on that foundation. Equally, Jacob's and Simondon's articulation of the ontological universality of energy may offer something of a criticism of Heidegger's contention that philosophy has sole claim to ontology, which is prior to and more fundamental than the work of the natural sciences, which provide only secondary and regional ontologies or ontic descriptions. Energy is not proper to a species of being, it offers instead a general description of beings, diminishing or even overcoming limits between regional ontologies, as Jacob clearly demonstrates. If conversions of energy are necessary for the being of beings, as Simondon contends, then a specifically philosophical claim to ontology is untenable. Equally, however, since there is not a scientific discipline specific to the study of energy in general - for physical, chemical, living and psychological conversions - then a specifically scientific claim to the study of energy may too be untenable. In this regard, Heidegger's claim regarding the ontic nature of scientific disciplines may be correct, and so too, Simondon's proposition that philosophy offers the capacity for recognising and expressing universality where other thinking may not. In contrast to Heidegger's claim for philosophical priority, the philosophical work of articulating the generality of energy must engage with scientific thinking, which is in many respects precisely *prior* to the work of philosophy.

Negentropic specificity

[112] Simondon, G. (2013), 63.
[113] Even with regards only to energy, he is one of very few - primarily Bergson, Deleuze and Stengers - to recognise its significance for philosophy.

Simondon's conception of transduction does not describe any and every being, however, nor does it describe all of those beings which convert energy from one form to another. Equally, the conservation of energy or its mere conversion are not enough to describe life or individuating beings. Rather, negentropy, or the use of available energy to do work, is the energetic description common to the individuating beings Simondon considers transductive.

We have already mentioned that beings like crystals or bricks are not transductive individuals, for Simondon. This is not simply because they are not becoming; indeed, we may contend that they are in fact becoming to the extent that they are undergoing a process of degradation or decay. This does not mean, however, that such beings are entropic whilst individuation is negentropic; crystals and bricks are already close to thermodynamic equilibrium or maximum entropy. Entropy is a systemic description, and a change in systemic or environmental conditions is required for further changes to the state of a crystal or brick (including degradation) which was previously at equilibrium.[114] In fact, Simondon writes very little about entropy, which may turn out to be a concern primarily associated with nineteenth, rather than twentieth or twenty-first century philosophy. Indeed, it has been increasingly recognised that on earth, non- or far-from-equilibrium thermodynamic states are less the exception than the rule, in large part due to a ready source of available energy, initially from the sun. Simondon's ontology does not describe beings near thermodynamic equilibrium nor imagine earth in that state.

Instead, transductive individuation describes beings which both use and require available energy in order to do work on themselves, or in order to continue to be. A brick or a crystal is at thermodynamic equilibrium, it does not convert energy in order to be. Equally, technical beings which convert energy from one form to another are not transductive individuals, in Simondon's sense, as they do not individuate, grow or act on themselves, but do work on an environment or being outside of themselves. In this sense, transducers like an audio amplifier or loudspeakers may use available energy for work with negentropic effects, but unlike a crystallisation or living beings they do not

[114] Common causes given for degradation of bricks, for example, are changes such as the following: water or frost penetration, shifting of the whole structure of which they are parts, exposure to vibrations, exposure to extreme temperatures, and exposure to rising damp (absorption of ground water). Each involves a *change* in the energetic conditions of the environment.

do work on themselves: they cannot grow or repair themselves, nor do they perceive and act in order to maintain their own being.

This helps explain Simondon's interest in metastability and potential energy, and clarifies the otherwise rather oblique sections on potential energy in *L'individuation*. In this way, we can read the whole of "Forme et energy"[115] as a reflection on the requirement for a source of available energy in order to do work *qua* individuation. "Potential energy", as Simondon expresses it, is thus an ability to do work requiring a relation to a source of available energy:

> the reality of potential energy is not that of an object or of a substance consisting in itself and "having no need for any other thing in order to exist"; in effect, it needs a system, that is, another term.[116]

As we have said regarding relation to a milieu, an individuating being requires a relation to an other *qua* source of energy; an individuating being is not a substance for which a relation is merely accidental. This substantial relation is a source of energy, and more precisely *available* energy.

In writing "available energy" we offer something of a precision to Simondon's text, which generally opts merely for "energy". According to the second law of thermodynamics, all energy in a system cannot be converted into work; available energy describes that portion of the total energy which *can* be converted into work. With this we follow Schrödinger's contention that organisms do not simply "feed on energy",[117] since energy in adult organisms remains broadly constant, and a mere exchange of energy for energy does not explain why conversion would be necessary. But we also agree with Peter A. Corning and Stephen Jay Kline that it is equally odd to argue, as Schrödinger does, that "an organism feeds on negative entropy".[118] This

[115] Simondon, G. (2013), 67-98.
[116] Ibid., 68. The quote "n'ayant besoin d'aucune autre chose pour exister" is unattributed, but it may be a misquotation of Descartes' definition of substance in *Principles of philosophy* as "une chose qui existe en telle façon qu'elle n'a besoin que de soi-même pour exister". Descartes explains in this context that God is the only substance that depends on nothing else, as all other substances depend on God and cannot exist for a moment "without being maintained and conserved by its power" [*sans être soutenue et conservée par sa puissance*]. The similarity between God and energy, in this sense (thus excluding morality and temporal necessity), is striking, though it goes unnoticed by Simondon. Descartes, R. (1904), 47.
[117] Schrödinger, E. (1967), 70.
[118] Ibid., 71.

overemphasises the role of entropy in the life of organisms, offering it as a driving factor for their seeking negative entropy.

We may add, further, that available energy also emphasises the extent to which energy is only available if it is compatible in its form with the capacities of a being. Most plants are able to transform solar energy and use it to do work, for example, whilst sunlight may simply come to thermal equilibrium on the skin of other organisms; the former is negentropic whilst the latter may be entropic. Solar energy is not simply a negentropy ready to feed organisms, rather its availability is a function of the ability of a being. To propose that organisms "feed on negative entropy" may thus underdetermine the requirement for relational capacities for transformation or transduction by a being. Available energy better captures the sense in which the use of energy for work is only made possible as a relation by compatibility between a form of energy and a capacity of a being.

This helps us understand metastability, the relevance of which is sometimes slightly occluded by the ambitious rhetoric of Simondon's introduction. Metastability describes the maintenance of potential energy, it is not at thermodynamic equilibrium or maximum entropy (the termination of an individuating being) nor, according to Simondon, does it describe a situation of chaos, or pure flux. Rather, those beings which Simondon describes as transductive must not reach thermodynamic equilibrium but must instead remain metastable, that is, they require a source of energy from a milieu which is converted into available energy which is used for individuation or individualisation.

Isabelle Stengers has criticised Simondon's claim regarding the generality of potential energy, arguing that the scientific theories that Simondon invokes pertain only to particular situations, and do not have the capacity for generalisation which he claims. Thus, with regards to *L'individuation* Stengers argues that "none of its results have a generalisable scope",[119] and with regards to energy, that

> In the breath of descriptive rhetoric, energy can certainly be generalised, but the generalisation not only loses the support of science but betrays what it rested on

[119] Stengers, I. (2002), 306.

> because it ignores the demands for nuptials against nature that constitute the theoretico-experimental relationship.[120]

Thus, Simondon would generalise energy in an empty, or merely rhetorical way which cannot be said to rest on the sciences, because it goes against the scientific or theoretico-experimental demand for "nuptials against nature". Stengers goes on to exemplify potential energy, proposing that whilst Simondon would generalise it, this contravenes "the fact" that "behaviours far-from-equilibrium no longer permit the construction of a function which plays the role of potential".[121]

The contradiction in Stengers' position is apparent even in this brief passage. On the one hand, she argues that philosophy cannot rest on the sciences, but rather it must *disrupt* scientific assumptions with nuptials against nature (*à la* Deleuze and Guattari), which at the same time constitute the "theoretico-experimental relationship". Thus, philosophy should bring together disparate elements - like an orchid and a wasp - in order to problematise scientific thought.[122] On the other hand, she criticises Simondon for getting the science wrong, for trying to generalise potential energy in spite of "the fact" that there is no potential function in far-from-equilibrium thermodynamics. The demand, then, is for nuptials against nature, but only when they do not contravene scientific "fact".[123]

A critical relationship to scientific description is no doubt requisite for philosophy, but whilst we will disagree the specificities and lacunae in his articulations of scientific theories, Simondon undoubtedly demonstrates this. A certain compromise is surely necessary, however, between established or verified scientific theory or fact, and critical attempts to destabilise or complicate it - with "nuptials against nature", for example. Indeed, it would be difficult to maintain, for example, that Deleuze's philosophy of difference does not rest upon and benefit from an identification with uncontroversial or widely accepted aspects of contemporary science (such as Riemannian geometry, the

[120] Ibid., 307.
[121] Ibid.
[122] Though even here, Stengers does not fully distinguish the work of philosophy and science, claiming that the latter makes similar nuptials against nature in its theoretico-experimental work.
[123] Stengers does not give any further examples of nuptials against nature other than Deleuze and Guattari's, and much of the critique of Simondon is for going against scientific orthodoxy - in following Louis de Broglie, for example.

arrow of time, cellular differentiation, and so on). This would also go against a swathe of literature on Deleuze and science, of which Stengers' is a part.

Only slightly more edifying is Stengers' more general claim, namely, that Simondon's expression of "energy" is ungeneralisable, or more precisely, that the conversion of available energy, or the use of potential energy in order to do work only refers to specific situations. It is correct that transductive individuation does not apply to any and every being or process; as we have been arguing, transductive individuation is limited to beings which use and must use available energy to do work. But to maintain that there is no potential function in far-from-equilibrium thermodynamics is not a problem for the philosophy of *L'individuation.* Stengers does not explain the potential function in far-from-equilibrium thermodynamics, but later in the text (responding to a question from Vincent Bontems), she offers a different definition. In that situation, she argues that "potential" suggests an "independence" from environment, that 'potential is there, independent from what happens, it is always available", and that it is thus "disturbing" when it comes to descriptions of life.[124] Now, there is no doubt that a capacity is relative to a situation (and not "independent"), but it is also worth remembering how general potential energy may be. It refers to the capacity to do work, which, for living beings, includes basic vital functions which must be performed in order to maintain existence. It does not mean that there is a potential to do work regardless of environmental conditions, of course, and if Simondon says little about the availability and unavailability of energy in milieux, this returns to our previous criticism of his rather unfulfilled expression of the nature and difference of milieux. This, however, amounts to a precision of Simondon's text, rather than a wholescale rejection of it, as Stengers claims.

Finally, Stengers does not give an explanation of the potential function in thermodynamics in the article in question, and for that we must turn to her text earlier written with Ilya Prigogine. Therein, "thermodynamic potentials" are defined as attractor states towards which systems tend if they have constant internal and environmental conditions. Thus, either maximum entropy S or a steady free entropy value F for a system of fixed temperature can be given as states which may be predicted

[124] Ibid., 316.

according to Ludwig Boltzmann's "order principle".[125] The difference when it comes to far-from-equilibrium thermodynamics, then, is that attractor states cannot be predicted according to Boltzmann's principle.[126] This has little to do with Simondon's expression of potential energy, however, as it merely articulates the necessity for an environmental source of energy for the being of individuating beings, as we have emphasised, and does not propose that entropy or minimum entropy production are attractors. Ultimately, what Simondon calls potential energy or metastability has little to do with what Prigogine and Stengers call "thermodynamic potentials".

Energy and information

We have seen that energy is general to physics, chemistry and biology in such a way as to provide a foundation for Simondon's single fundamental operation, which describes individuation in different branches of science according to cybernetic analogy. We have also briefly discussed the sense in which transductive individuation is limited to negentropic beings, or those which use convert available energy and use it to individuate.

Before we conclude, there is a final aspect of Simondon's reflection on energy which has to do with particular beings to which transductive individuation applies: information. The distinction between energy and information is a vexed question - both for Simondon's work and more generally - which may be attributable, in large part, to different definitions of the same term. In information theory, "entropy" measures the relative uncertainty in a message (and "information" measures relative improbability), whilst in thermodynamics "entropy" measures energy within a system which is unavailable for work and available energy or negative entropy measures energy within a system which is available for work.[127] Although attempts at identification between the

[125] Prigogine, I. and Stengers, I. (1984), 122-126.
[126] Ibid., 138-140.
[127] In this sense, "entropy" for Shannon's or Wiener's theories of information is a quantitative measure of uncertainty of the group of characters from which a message is selected, whilst the "information" or negative entropy of a message describes the improbability of that message, relative to the uncertainty of the set from which it was selected. As Wiener puts it, "the more probable the message, the less information it gives." For thermodynamics, entropy is a measure of energy unavailable for work, whilst available energy or negative entropy is that which can be used for work. Whilst entropy, in the two descriptions, may be broadly identified as more probable, the similarity goes little further than that. Equally, information and available energy are both relative to the entropy of a system, but information is a measure of improbability not meaning, and thus in vastly simplified terms, it may not be able to do work on a receiver. Wiener, N. (1989), 39.

meanings of entropy and information in information theory and thermodynamics are regularly attempted, ultimately, they may be too disparate for this to be possible. (The definition from information theory is not that which interests us here, however, though we will return to it in chapter three.)

Often energy is simply exchanged for information. Thus, as we mentioned, in Graf's definition of a transducer physical information is indistinct from energy: "a device that converts information from one physical form to another". Equally, energy is often called information when it describes animal sensation or perception. Jacob, for example, writes that "Today, living beings are seen as the site of a triple flow of matter, energy and information",[128] but one wonders in what sense information "flows". Rather, his definition tends to focus on the sense in which information involves the capacity for receipt and repetition. For Jacob, too, this is also almost to argue against himself, as he emphasises the extent to which energy is universally convertible: "Everything that a living being could accomplish in terms of movement, electricity, light or noise" is a conversion of energy.[129]

For Simondon, information is not equated with the contents of a message, as in the definition from Norbert Wiener or Claude Shannon. Nor is it generally confused with the receipt of sensation. Rather, as we will see in the following chapter, information is primarily considered in light of the notions of command and control, which involves the orientation of the transformation of energy. We have argued that individuation is negentropic, for Simondon, and we can add that this requires a particular transformation of energy, one which makes "use" of energy in some way. Energy is available because it is compatible with a being, and this compatibility describes the capacity to transform available energy in a negentropic manner. The negentropic transformation of energy, or the work is individuation, whilst information describes the operation which commands and controls the conversion of energy in order that it generates in a particular way.

Conclusion

[128] Jacob, F. (1970), 109 [95].
[129] Ibid., 212; 220 [194; 201].

This is only the very beginning of our discussion of Simondon's conception of information and energy, of course. We have yet to discuss the actual role of energy and information for transductive ontogenesis or individuation, to which we turn in the following chapter.

Before moving on, it is worth briefly recapping what we have discussed thus far. We began with a reflection on the meaning of the word transduction, for Simondon, arguing that its roots lie in the technical conception of a transducer, a device which converts energy from one form to another. As electronic devices, transducers are found almost everywhere today, and in enormous variety, but this is not quite the sense which Simondon intends. Rather, he is primarily interested in transduction, an operation rather than a device, and the way in which it might provide a universal description for individuation or ontogenesis that is equally applicable to various branches of natural science. We thus examined Simondon's early discussions of cybernetics as an "inter-scientific technique" which makes use of operational descriptions general to different branches of science. In this sense, we proposed that transduction is to Simondon's philosophy what homeostasis is to cybernetics: an operational analogy applied to different kinds of being studied by different branches of science. Transduction is the operation Simondon attempts to apply to "any" individuation or ontogenesis.

In this regard, we also emphasised the sense in which Simondon's conception of transduction comes after scientific descriptions, offering an operation compatible with or common to them. We will see throughout this thesis that Simondon's philosophy of transduction builds on scientific descriptions, producing a general conception of individuation by working with the sciences. Science comes first and philosophy second, resting on and developing the theoretical descriptions of the former.

We then discussed Simondon's critique of substance, to the extent that it describes a being for which relation is accidental. Transductive beings require energy from a milieu in order to continue to exist, and they are in this sense dependent on this relation. Relation is thus not accidental but substantial, for transduction. Whilst Simondon levels this criticism very broadly - at atomism and hylomorphism, the "two ways" according to which individuation has been hitherto thought - we proposed that the substantiality of relation has a significant philosophical and scientific history prior to Simondon's work,

seen in terms concepts used in the development of ecology. We thus offered a brief history of the relation between living being and milieu, which allowed for an acknowledgement of Simondon's more subtle contribution, namely a reflection on the energetics of relation which is often underestimated. Both Uexküll and Heidegger defend a conception of relation which privileges perception, the capacities which make the worlds which particular beings inhabit possible. But both seem to miss the sense in which these capacities - vision, hearing, touch, and so on - are conversions of energy. Moreover, neither discuss the relation which produces and sustains beings, the conversion of energy which makes possible coming into being and the maintenance of being. One of Simondon's major insights, then, is that substantial relation to a milieu ought to be considered necessarily energetic. Living beings must convert energy in order to continue exist, whilst the perceptual world that they inhabit is equally constituted by the sensorial conversions of energy.

Finally, we discussed the sense in which energetics provides a universal foundation for Simondon's philosophy of transduction. His contention that transduction applies equally to physical, chemical and vital individuation is thus underwritten by the acceptance of energetics in those branches of science. Whilst conversions of energy may describe any and every genesis, transduction applies only to beings which use available energy to do work on themselves, or indeed, transduction is specific to negentropic genesis.

Chapter two - The work of transduction

In the previous chapter, we discussed the conceptual precursors, conditions and the method for transduction in very general terms - its conditions of possibility - we now turn to the actuality of transduction within *L'individuation*. In this way, we emphasise both the practice of Simondon's analysis, focussing on the role of scientific examples, and the consistency and conceptual development of transduction across different examples and branches of science. Equally, whilst emphasis in the previous chapter was laid on energy in Simondon's ontology, this chapter focusses on information, the operation which orientates the transformation of energy - according to functions of command and control - and which describes the work of transduction. Transduction is not any transformation of energy, as we have said, but a negentropic one and one which generates and maintains beings.

The engagement with *L'individuation* in this chapter is fairly fine-grained, and pays close attention to Simondon's use of examples as means for generating problems and conceptual resolutions. Whilst other readers have made significant contributions to understanding the work of transduction and the nature of Simondon's thought more broadly, we contend that there has been an underestimation of the importance of transduction as it appears in *L'individuation*. The details of Simondon's discussion are often neglected, emphasising instead the broad sweep of his argument. This has certainly proved fruitful in attending to the general stakes of his position, but it overlooks some of the specificities which are, ultimately, crucial for the possibility of transduction. In this respect, whilst many take Simondon's comments in the Introduction as an apt expression of transduction, we contend that it can only be understood as it develops in the first two parts of the text. Attention must be paid to transduction as it is expanded in light of new problematic examples and domains. We thus examine sections in *L'individuation* which are seldom discussed, but rather than focussing on oversights on the part of readers, our primary aim is to grasp transduction as it develops according to theory and examples from the natural sciences.

Attention to the specificities of the development of transduction serves to demonstrate its successes in application to a range of different domains and beings, but it equally

gives us insight into some of the limitations of Simondon's argument. Most broadly, we demonstrate that Simondon's conception of analogy, which would identify different beings according to their manner of genesis, is at least complicated, if not significantly undermined by the development of the concept of transduction. If analogy were simply a case of identifying the same operation of genesis between two beings, there would be no need for development throughout the text. Equally, when it comes to the individuation of living beings, we discuss the tension between Simondon's argument for a substantial relation upon which a being depends for its existence, and the extent to which individuality, according to Simondon, does not exist either at the level of the atom or the whole of life. In this way, he maintains that living individuals are in one sense dependent on but in another independent from one another, this requires Simondon to make a number of complex arguments regarding the nature of this dependence and independence which have been underestimated by his readers. Ultimately, as we contend, this conception of relation forces Simondon to take a historically doubtful quasi-Lamarckian position regarding genes, which is incompatible with contemporary genetic arguments and neo-Darwinian orthodoxy.

1. Examples

Reading either of Simondon's doctoral theses, one of the first things one is struck by is the sheer quantity of examples. The role of examples is rarely remarked upon by readers of Simondon's work, but they are crucial for both theses. Thinking, in both of Simondon's major texts, happens through the analysis of examples. In order to grasp a concept in *Du mode,* Simondon analyses examples, often in fine technical detail. To express concretisation, for example, the text works through different and progressive instantiations of vacuum tubes, the Guimbal turbine, and carburettor cooling fins. These examples are not given after the definition of a concept, in order to aid comprehension of an unfamiliar thought, but rather, they are the focus of the writing and the source of thinking. Close and detailed discussion of unfamiliar technical objects often takes priority over the definition of concepts, and the text often reads as if conclusions are being drawn in the moment, that we are philosophising along with the text rather than fulfilling a predetermined argument. But whilst Simondon acknowledges the unfamiliarity of examples in *Du mode*, supplying diagrams and definitions in an appendix, he offers no such help for *L'individuation*.

L'individuation works with examples in a similar way. The argument for transduction primarily takes place through the analysis of examples which are derived, in the main, from natural scientific thinking. Reference to the history of philosophy or to other philosophical texts is generally made at the beginning and the end of the "parts" of the text (physical, vital, psychic and collective individuation) and only briefly in the main text of those sections; in the main, the text pursues examples in order to derive concepts for individuation.[130]

Examples have a double function for transduction in *L'individuation*. First, they are analysed in order to articulate concepts used to express transductive individuation. Discussion of crystallisation thus produces concepts for transduction - relation, energy and information - and these concepts are then developed through analysis of further problematic examples, such as the unity and novelty of living beings. Second, examples provide evidence of transductive beings, partially justifying the claim that transduction applies to "any" individuation. Clearly, it is impossible to give evidence for the application of transduction to any individuation, but Simondon is nonetheless preoccupied with justifying the application of transductive individuation to various different "domains" of individuation. He stresses that transduction is applicable to both physical and vital individuation - that it is not a vitalism - and gives evidence for this through discussion of examples from different branches of science (which organise the sections of the text according to physical, vital and psychic individuation). Evidence for the transductive nature of individuation is thus provided in each different domain of individuation, or indeed through analysis of the particular beings of particular branches of science. Examples thus provide evidence for the capacity of transduction as an operation which might be applied to a range of disciplines by an "inter-scientific technique" that we discussed in the previous chapter.

It ought to be stressed that these examples in *L'individuation* are made possible by scientific theory, and in many cases scientific texts. Simondon's work develops concepts through the analysis of examples, but those examples themselves result from prior hypothesis, experimentation and rectification in the natural sciences. This is not an observation of the development of a natural consciousness, as we see in Hegel's

[130] A number of sections in which Simondon engages with the history of philosophy were also omitted for the first publications of the text but returned for the current published version.

Phenomenology of Spirit.[131] Rather, Simondon's work deals with secondary experiences, or those made possible by scientific theories and concepts which have already undergone hypothesis, partial failure and rectification. The examples which provide the basis for transduction are made possible by scientific theories which assume the historical development of science.

"*Paradigmatisme*"

Examples abound in Simondon's philosophy, but some are more significant than others, and one in particular. Indeed, Simondon is self-conscious about the use examples for his transductive philosophy and introduces crystallisation early on as the "paradigm" and the "the simplest image of the transductive operation".[132] Although his extensive use of examples is often underexplored by readers (which we will discuss in a moment), the strategy to position crystallisation as the prime example has paid off: it is hard to find a discussion of Simondon's work without at least a mention of crystallisation, which often serves as a starting-point for the expression of transductive individuation.

As with each example, the analysis of crystallisation produces concepts used to express transduction and provides evidence for its applicability. It is used comparatively, and referred back to throughout *L'individuation* in order to demonstrate the continuity and development of transduction. He does not explain why crystallisation is the "paradigm" (subatomic particles, his other "physical" example, seem more obviously simple), but he nonetheless describes and uses it as such.

Before arriving at crystallisation, however, Simondon makes a critique of hylomorphism through an analysis of brickmaking, an example which he refers to as the "paradigm" for hylomorphism.[133] Thus, it is not the paradigmatic method or even the "technological" hylomorphic paradigm which fails, according to Simondon, but the hylomorphic analysis of the paradigm. Hylomorphism is unsuccessful because it ignores energy and relation; it has a static, actualised or individuated image of an individual, and works backwards introducing a principle to explain its genesis. These problems are associated with the particular analysis of the hylomorphic paradigm, not with a paradigmatic

[131] Hegel, G. W. F. (2018).
[132] Simondon, G. (2013), 32.
[133] Simondon, G. (2013), 45; 50.

method *per se*, or with a technological paradigm. Rather, hylomorphism and the hylomorphic tradition from Aristotle onwards obscures real genesis by introducing a principle of individuation in order to explain the creation of already individuated beings. The problem is thus not the use of example or analogy - the paradigmatic method - to express genesis, but that a principle of individuation stands in for the mediation or the meeting of matter and form, concealing genesis proper.

We said previously that Simondon admires Aristotle's hylemorphism. In this way, the whole first section of *L'individuation* engages in a critical *rectification* of hylomorphism, illuminating the obscure zone and introducing energy and relation into the analysis of the example.[134] Simondon thus writes that

> We would like to demonstrate that the technological paradigm is not devoid of value, and that up to a certain point it permits thinking the genesis of the individuated being, but on the express condition that one retains, as an essential schema, the relation of matter and form across the energetic system of taking form.[135]

Even with a rectified hylomorphism, however, the technical paradigm cannot be properly applied to all beings. It applies to beings which are individuated in a brief period of time, but not those which continue to individuate (so long as there is available energy). Hence, in the passage above he writes that the technological paradigm affords thinking the genesis of the "individuated being", that is, not the individuat*ing* being. The technological paradigm thus

> cannot be extended in a purely analogical manner to the genesis of all beings. The technical operation is complete in a limited time; after actualisation, it leaves a being partially individuated, more or less stable, which takes its haecceity from this operation of individuation having constituted its genesis in a very short

[134] True to Simondon's mode of analysis, too, examples are crucial and plural throughout this whole section: those of brickmaking, mould-making, cutting and planing wood, rolling mills and electronic tubes are all discussed.
[135] Ibid., 47.

> time; the brick, after several years or several thousand years, becomes dust once again.[136]

As a paradigm, then, brickmaking only applies to beings actualised in a limited time. It is not a continual genesis, but one which is completed, or which reaches fulfilment in a "limited time". Aristotle was not wrong in making a technical analogy, then, but in applying it to living beings. Equally, however, Aristotle misunderstood the technical operation, ignoring the mediation between matter and form and replacing it with a principle, as Simondon argues in the first section of the text. Thus, a new concept is needed to replace hylomorphism - transduction - and a new paradigm to replace brickmaking - crystallisation.

This is a significant moment in the text, as it is here that Simondon effectively limits the geneses to which his transductive analysis will apply. Indeed, whilst he writes above that Aristotle's technical paradigm "cannot be extended in a purely analogical manner to the genesis of all beings", properly speaking, neither can transduction, since it does not apply to genesis as degradation - such as the becoming-dust of the brick. A surprising consequence, in this regard, is the omission of individuated beings, including technical objects from the analysis.[137] Simondon does not explain the nature of an individuated being, and thus, the relationship between a consciousness and an object - a significant question for a great deal of post-Kantian philosophy - is left behind at this point in the text.

The analogical act

Simondon affirms Aristotle's use of analogy and, as we saw previously, he is impressed by the hylomorphic capacity for generality. In this way, he argues that analogy, with an appropriate paradigm example, can achieve the generality at which transduction aims. He is clearly interested in using a paradigm for transduction - reflecting on the possible paradigmatic status of technical objects in an early text[138] - and in a concept of analogy

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[136] Ibid., 48.
[137] *Du mode* does not supply an answer either, as the modes of existence of the object analysed therein are either relative to a milieu (not a living being), or as instantiations in the genesis of a technical lineage or species.
[138] "L'ordre des objets techniques comme paradigm d'universalité axiologique dans la relation interhumaine (introduction à une philosophie transductive)", Simondon, G. (2016), 421-453.

which could bring together various operations. Such a concept of analogy is discussed in "Alagmatique", a draft written prior to the submission of his theses which we discussed briefly in the previous chapter.[139]

In Allagmatique, Simondon reflects on the sense in which an "analogical act" can make an identification between two "operations" which arise from two different "structures".[140] He cites Plato's *Sophist* as the source for this conception of analogy, and more specifically, the analogy of the operations of the sophist and the angler: the former "lures" "young rich people" whilst the latter "lures" fish. "Lure" is thus the operative word, which describes an identical operation between two different "structures", sophist and angler.[141] In this context, "structure" is the functional equivalent of a being or the essence of a being, such that "sophist" and "angler" are the structures from which the operations - luring - proceed. Structures may differ, but the operations are the same.

What is important about this conception of analogy, for Simondon, is that it affords an identification of operations between different beings. Different kinds of beings may enact the same kind of operation. Thus:

> The analogical act is the putting in relation of two operations. It was employed by Plato as a logical method of inductive discovery: *paradigmatism* consists in transporting an object of thought, learnt and felt from a particular known structure (for example that which serves to define the angler in the *Sophist*) to another particular structure [which is] unknown and [the] object of research (the structure of the sophist in the *Sophist*). This act of thought, transfer of operations, does not suppose the existence of a common ontological terrain of the angler and the sophist… It does not seek in any way to prove that the angler and the sophist result from the imitation by the Demiurge of a common model: logical *paradigmatism* liberates itself from *exemplarism*.[142]

Sophist and the angler are different structures, but they enact the same operation of luring. There is an operational analogy between two beings without "the existence of a

[139] Simondon, G. (2014), 532.
[140] Ibid., 532
[141] Plato (1921).
[142] Simondon, G. (2014), 532 [italics original].

common ontological terrain". An ontological category or "particular structure" is thus indifferent to an operation. "Paradigmatism" does not seek to identify the acts or operations associated with a particular kind of being - attempting to prove that sophist and angler result from a common essence. Rather, this approach seeks analogical operations or acts arising from structurally or essentially different beings - those without "common ontological terrain".

Simondon proposes that paradigmatism was used by Plato as a "method for inductive discovery", for hypothetically identifying a known structure with an unknown structure. To a certain extent this describes the movement of *L'individuation*, from the operation of crystallisation to living beings. It might also serve to emphasise the extent to which the text pursues an open question rather than merely explaining the answer. However, it ought to be noted that the work of transduction is not simply inductive; it is not a case of explaining the operational identity of all of the beings which individuate as a crystal does. Instead, transduction develops as it moves through various stages, and as we shall see, living individuations involve problems which physical individuations do not. In this way, a full expression of transduction is only really given at the end of the text, or at least at the end of the section on vital individuation, once its whole conceptual development has been completed within *L'individuation*.

We see clear similarities here between the "cybernetic analogy" that connects branches of science (which we discussed in the previous chapter) and operational analogy between two structures. In this way, later in the text Simondon writes that allagmatics "organises and defines the relation of the theory of operations (applied cybernetics) and of the theory of structures (determinist and analytic science)."[143] Similar to the early texts previously discussed, cybernetics is here considered "a theory of operations" which works with natural scientific descriptions, or branches of science which are considered theories of structures.[144] Homeostasis is perhaps the most obvious of such cybernetic operations, applying equally to the acts or operations of many different kinds of beings - anti-aircraft guns, boilers and living beings alike.

[143] Ibid., 535.
[144] Ibid., 535.

This gives us a clue to Simondon's use of examples in *L'individuation*: the same operation of genesis is found in examples of different kinds of beings, which are proper to different branches of science. But we must also recognise that whilst Plato's *Sophist* or cybernetics begin with conceptions of operations in hand (luring or homeostasis, respectively), and can thus move inductively, adding the operations of further beings to this category, the same cannot be said for transduction. Simondon does not begin *L'individuation* with an articulation of transduction and merely delineate or discover further beings which may be included. Rather, the analysis of examples determines transduction, which develops along with the text. A plethora of concepts and distinctions are given when we get into the actual work of *L'individuation*, including a number of subtle distinctions between examples, especially when Simondon discusses living beings.

Examples force transduction to develop. Simondon's discussion of transductive individuation in the Introduction gives only a simplified version which is complexified and enriched through engagement with different examples throughout the rest of the text, something which is clear even with regards to crystallisation, the "simplest" example of transduction.[145]

2. The example of crystallisation

Simondon sets-up crystallisation as a paradigm for transduction, as brickmaking is the paradigm for hylomorphism,[146] to the extent that it ought to be applicable by analogy to individuations in other domains. The crucial difference, according to Simondon, is that brickmaking can apply by analogy only to those beings whose (negentropic) genesis is brief, whilst crystallisation applies to those beings whose genesis continues so long as they exist - beings for which being equates individuating. Brickmaking may be applied by analogy to the genesis of beings with an existence which does not require available energy to persist, whilst crystallisation may be applied to individuations which require available energy in order to exist.

[145] Simondon, G. (2013), 32.
[146] According to Simondon's text, at least.

In order to achieve a paradigm which might be analogically applicable, however, significant conceptual work is required. Simondon argues that hylomorphism ignores the subtleties of processes of information and demonstrates this with a detailed discussion of the technical processes of preparing "matter" and constructing "forms". In much the same way, crystallisation should not be read according to Simondon's highly simplified (yet oft-quoted) comments in the Introduction.[147] Many readers focus too much attention on crystallisation as it appears in the Introduction, underestimating the significance of the conceptualisation in the section on crystallisation.[148] There is also a resultant tendency to overemphasise the concepts of supersaturation and metastability, which are stressed in the Introduction but have less significance later in the text. The Introduction contains some of Simondon's most stylish writing, but (like many introductions) it lacks the fine-grained discussion of the rest of the text. In the same way that Aristotle's matter and form pair can appear deceptively simple, so too, the expression of transduction-as-crystallisation often belies its complexity.

As we read it, the analysis of the example of crystallisation is crucial in order to develop concepts for transduction, which are used throughout Simondon's text. In the following section, we attempt to give a precise reading of the conceptual development associated with crystallisation, emphasising five concepts which arise in this section: phases of matter, limitation, information, the temporality of individuation and elementary multiplicity.

[147] Such as the following: "A crystal which, from a small seed, grows and extends itself according to all the directions in its mother-water offers the simplest image of the transductive operation: each molecular layer which is already constituted serves as a structuring basis for the layer in the process of formation; the result is a reticular amplifying structure." Simondon, G. (2013), 32-33.

[148] For example, Jean-Hugues Barthélémy's chapter "Transduction" et cristallisation: le scheme et le paradigm" in *Simondon ou l'encyclopdédisme génétique* cites a long passage from the introduction but does not discuss the section on crystallisation in *L'individuation*, or its conceptual significance. Whilst Barthélémy reflects on the broader significance of a universal paradigm or schema, in this passage, crystallisation itself remains opaque. Barthélémy, J-H. (2008), 61-66. Similarly, Barthélémy's chapter in *Penser l'individuation: Simondon et la philosophie de la nature* ("Le paradigm de la cristallisation") cites at length from the introduction but ignores Simondon's detailed discussion of crystallisation in *L'individuation*, moving quickly to a discussion of the relationship between crystallisation and life. In both texts, whilst Barthélémy makes thoughtful contributions to grasping Simondon's project at the broadest level, they are undermined by his quick reading of crystallisation. Barthélémy, J-H. (2005a), 152-158.

Phases of matter

The concept of phases of matter allows Simondon to offer a rectification or transformation of the hylomorphic concept of matter. Indeed, whilst the notion of uninformed matter is a problem for Aristotle's hylomorphic analyses of genesis or of being,[149] phases of matter do not require a conception of pure matter, but rather view different states of matter relative to systemic energetic conditions. In this way, for Simondon there is no problem regarding whether matter can exist without form or form without matter prior to individuation. Rather, matter is always informed or phased, and the individuation of a crystal involves a material phase change.

Simondon's exposition of phases of matter works through a discussion of Gustav Tammann's Hypothesis regarding the necessary relation of energy to phases of matter. In this way, systemic energetic conditions - pressure and temperature - serve to determine particular phases of matter - gaseous, liquid, vitreous and crystalline. This serves to combine Simondon's previous discussion of potential energy with a theory of matter. His interest here is to demonstrate the sense in which the "structural" state of matter is determined by the energetic magnitudes in a system. Thus, in the graph Simondon supplies (Figure 1 below), the *x* axis depicts temperature and the *y* axis pressure. The four regions represent the determination of liquid, gaseous and vitreous states relative to magnitudes of pressure and temperature.

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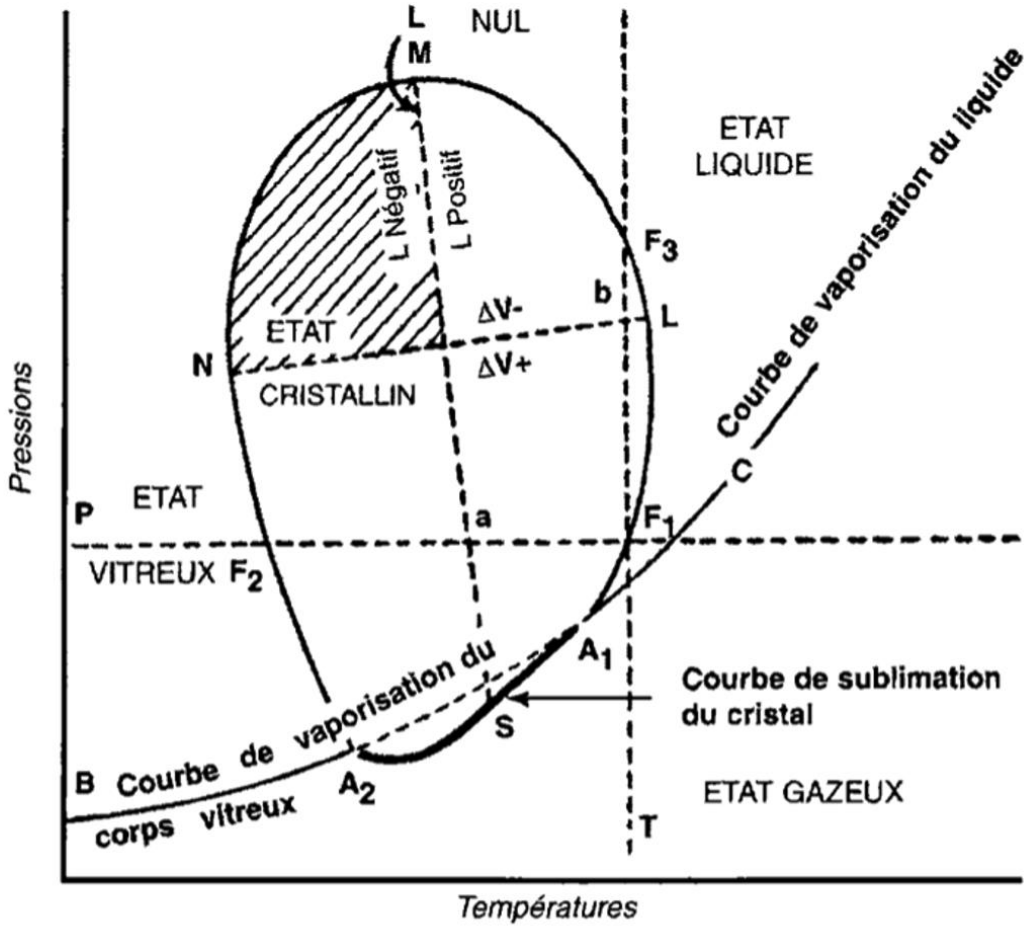

Figure 1: "*Domaines de stabilité des différents états.*" [150]

The hylomorphic concepts of matter and form are thus replaced by phases of matter relative to energy. Form, in this example, does not determine an indeterminate matter, rather the phase or "structural" state of matter is determined by particular magnitudes of temperature and pressure. Thus, Simondon writes that "The limits of the domain of stability of a structural type are determined by energetic considerations".[151] Stable structural domains, or phases of matter are determined by energy - temperature and pressure - and not by form.

Whether or not one chooses to call phases of matter (gaseous, liquid, vitreous, crystalline, plasma) "forms" of matter, they are not determinations of matter by a form. This avoids the problem of uninformed or prime matter with a theory of relations between elements which produce different phases, or structural states. Equally,

[150] Simondon, G. (2013), 74.
[151] Ibid., 76.

Simondon writes that "In the domain of crystalline structure, for example, one sees how the ancient notion of *elements* must give way to a theory at the same time structural and energetic".[152] Phases of matter do not result from mixtures of fire, earth, air and water, but from states of energy and matter. This demonstrates the way in which Simondon makes a critique of ancient metaphysics using contemporary scientific theory and example.

The change of a phase of matter, however, is not necessarily an individuation. An individuation with regards to this example, according to Simondon, requires a change from amorphous to crystalline. Whilst the speed of molecules in gaseous, liquid and vitreous phases are different (they are slower in each phase respectively), the structural state of each is the same, unlike the crystalline phase, these phases are anisotropic, their molecules have no privileged direction. Crystalline solids, on the contrary, are isotropic. Thus, Simondon writes, "according to Tammann's hypothesis, the crystalline state would be characterised by the existence of privileged directions in crystallised substances".[153] Privileged directions refer to crystalline networks, which enable the categorisation of different types of crystal.

Crystallisation is unlike other phase changes because it organises molecules of a substance. As Simondon emphasises, an individuated crystal has a periodic or repetitive structure, an organisation which determines it as a crystal. Crystallisation involves an organisational distinction, between an amorphous liquid and a crystal, or the limit of a crystal from which crystallisation proceeds. Whilst many readers focus on the "seed" which begins and maintains the organising operation of crystallisation, we might better read this as a transduction, that is, as a transformation of energy and matter.[154] What is crucial is that there is a transformation of the organisation of the molecules of a substance. This transformation, according to Simondon, involves the use of available energy in the substance in order to make this reorganisation.

[152] Ibid., 72.
[153] Ibid., 73.
[154] See, for example, Combes, M. (2012); Mills, S. (2016).

Limitation and information

Simondon expresses crystallisation as a limit between a crystalline seed or the limit of an already crystallised portion of substance and an amorphous portion of substance. Crystallisation happens at this limit, which transforms energy from the milieu in order to reorganise molecules according to a new crystalline arrangement. One might picture a portion of substance gradually crystallising, moving outwards and crystallising at the edges of previously crystallised substance. The individual, Simondon argues, is this limit moving through the substance, the individuating or crystallising moment between individuated or crystallised substance and amorphous substance.

The notion of the limit, here, is significant in two respects. First, it is that which differentiates an individual from a milieu, the unity and self-identity of an individual relative to a milieu considered other. Second, it is that which transforms energy and commands its activity or individuation, what Simondon calls "information".

A crystallisation begins when a crystalline seed initiates a transformation of the phase of matter from amorphous to crystalline. The amorphous substance is constituted as a milieu because a limit is introduced which distinguishes a crystallising operation from the amorphous substance. As we have discussed, this is a distinction between aleatorily distributed molecules and molecules organised in a crystalline structure. It is this difference which constitutes the unity of the individual in distinction from the milieu. Whilst this individuating limit *is* a relation with the milieu, it is one of self-differentiation. Equally, whilst the limit depends on the milieu for energy, it nonetheless distinguishes itself from it according to the way in which it transforms that energy; this offers us the clue for the distinction between energy and information in this section.

Like all individuations, for Simondon, crystallisation requires available energy from its milieu in order to individuate and continue individuating. The limit transforms available energy from the amorphous substance, using it to do work. The work, in this situation, is the rearrangement of molecules in the substance - from amorphous to crystalline distribution. The transformation of energy, then, is quite clear in this example. When Simondon refers to the seed or the limit as "information", however, it is not always obvious exactly what he means. He does not pause to define information in this section, and when he thematises and defines information at length some 150 pages later, the

focus of the discussion is a criticism of cybernetic and information-theoretic conceptions rather than the ontogenetic theme pursued throughout most of the text.[155]

Clearly, information in this situation is not like a message received from the milieu - as one might say that aural "information", for example, is received by a living being from its environment. Equally, Simondon moves away from cybernetic or information theoretic conceptions, whereby the information of a text, for example, could be given a value. Information, for Simondon, is an operation, not a value contained in a text or a signal, for example.

Whilst almost all readers acknowledge this negative component of Simondon's definition, they generally fall short of explaining exactly what the operation information is. Simon Mills, for example, offers an edifying comparative discussion of information in cybernetics and Simondon's work, and helpfully notes the variety of meanings Simondon accords information - as a synonym for individuation; a state of disparity or problematicity; actual communication and meaning.[156] But Mills does not explain how information specifies individuation, or the sense in which it is not merely a synonym for individuation. Jean-Hugues Barthélémy also offers an interesting discussion of Simondon's aims when it comes to information - to move beyond cybernetics and find a universal description for individuation.[157] But again, whilst apparently pursuing "The question of "information"", Barthélémy does not explain how information is different from individuation, or how information helps to define and think transductive individuation.[158]

Now, there are multiple facets of Simondon's definition of information in *L'individuation* (we will discuss another in the following chapter), and equally, on occasion, Simondon expresses information such that it is effectively indistinguishable from individuation. We contend, however, that there is at least an *aspect* of Simondon's definition of information that both specifies individuation and is maintained throughout the text.

[155] Simondon, G. (2013), 219-223.
[156] Mills, S. (2016) 44-51.
[157] Barthélémy, J-H. (2008), 66-75.
[158] Muriel Combes recognises that it is unlike Norbert Wiener's definition, but ultimately does not distinguish information from individuation, proposing that information is "nothing other than the internal resonance of a system in the process of individuating, the power radiating between one domain of individuation and another". Combes, M. (2013), 5; 64.

In short, for crystallisation as for living beings, information is an operation of command. Whilst available energy is derived from the amorphous substance (and to this extent the individuating limit depends on the milieu), the limit effects a command over the molecules in the substance, reorganising them from amorphous to crystalline arrangement. The former is the energetic and the latter the informational component of individuation. Thus,

> as soon as the seed is present, it possesses the value of a principle: its structure and its orientation control [*asservissent*] this energy of the metastable state; the crystalline seed, providing only a very weak energy, is capable nonetheless of driving the structuration of a mass of matter several billion times greater than its own.[159]

Thus, the seed or the limit governs the available energy derived from the milieu. The limit uses its own "weak energy" to orientate that of the milieu to re-organise molecules. It has "the value of principle" in the sense of a governance, command or subjugation (*asservissement*): the limit of the crystal governs or commands the molecules of a substance.[160]

This exhibits the cybernetic sense of governance which is given, for example, in James Clerk Maxwell's founding text "On Governors".[161] A governor, in this sense, maintains the velocity of a machine according to a process of homeostatic regulation. The functioning of a device - like a steam engine - is regulated or controlled by a minor element which determines some aspect of the working of a machine - a Watts governor maintains steam flow, and thus the speed of a steam engine, for example.[162]

But we also note a distinction here between crystalline governance and that of regulation or homeostasis. Whilst a *homeostatic* governor regulates the activity of a

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[159] Ibid., 86.
[160] The fifth sense Aristotle ascribes to *arche* in *Metaphysics* book "Delta": "That by whose choice that which is moved is moved and that which changes changes, e.g. the magistracies in cities, and oligarchies and monarchies and tyrannies, are called origins." Aristotle, (1991) *Met.* 1013a12-15.
[161] Maxwell, J.C. (1868).
[162] In a Watts governor, as the speed of a machine increases, two arms attached to a central spindle are lifted by centrifugal force as the spindle spins. The arms are connected to control valves which reduce steam flow if lifted and increase it if lowered. Thus, if the speed of the engine increases, the arms are lifted by centrifugal force and less steam is allowed into the engine, ultimately reducing speed. If speed decreases, the arms are lowered, the valve opening increased and more steam is allowed in, increasing speed. Ultimately, the mechanism regulates speed, maintaining it within a desired range.

machine or a being according to feedback, the crystalline seed only commands, it does not respond to feedback. A homeostatic boiler, for example, responds to feedback or an information signal from the exterior milieu and enacts a command accordingly. If a signal detects temperature above the desired range, for example, the boiler will lower its power output until it receives a feedback signal within the desired range. Whilst a homeostatic device effects commands over some aspect of the device (controlling the temperature of a boiler or the steam intake of a steam engine, for example) in response to feedback, the crystalline operation of information only commands, there is no feedback or regulation to speak of. This is perhaps the key difference between the individuation of crystals and living beings, according to Simondon: crystallisation is not homeostatic, whilst vital individuation is.

Available energy is thus derived from a milieu in order to do work and information is the operation which orientates that energy as a command. Information describes the operation of command which determines a transformation of energy as work (otherwise it is entropic) reorganising the molecules of amorphous substance into a crystalline arrangement. The difference between individuation and information, then, is slight but significant. Individuation is the whole operation, the conversion of available energy *and* the reorganisation of molecules. Whilst information describes only the command which orientates the conversion of energy.

Temporality

We have seen that the crystalline individual is a limit between crystallised and amorphous matter, and that it involves a transformation of the molecular structure from amorphous or disordered to a repetitive crystalline order. But whilst Simondon is quite clear that crystallisation is an individuation in so far as it changes the molecular structure of matter from amorphous to crystalline, he argues that the crystal left behind after crystallisation is not an individual. Simply put, this is because an individual, for Simondon, must be an individuation. The limit is thus temporal, a transform*ing* limit which moves through the milieu. Whilst the limit might be considered like a transducer from the field of electronics to the extent that it transforms energy, unlike those transducers, the crystallising limit is not a fixed structure which remains self-identical

whilst transforming an external input. Crystallisation is a transformation of energy, but it is also itself a transformation, lacking the self-identity of a technical being.

As a transforming limit, the crystallising individual is perpetually in the present, according to Simondon.[163] The individual is not an individuated being, but a "perpetually unachieved"[164] individuating being. This requires both an activity of limiting and transforming on the part of the individual, but it also requires that the milieu provides molecules and energy to continue individuating. In this way, Simondon argues that crystallisation has "an indefinite power of growth; a crystal can have its growth stopped, but never achieved".[165] If a milieu harbours enough energy and matter, then, a crystallisation will continue indefinitely. Although this might seem particular to crystallisation, we will see that Simondon argues that living beings at the level of colonies, societies or species are similarly indefinite; their growth might be stopped by some external event, but termination is not a necessary and immanent aspect of their being.

Crystallising, according to Simondon, expresses being and becoming together, rather than opposed to one another, and more specifically the sense in which time is asymmetric and irreversible:

> Temporality, as it expresses or constitutes the most perfect model of asymmetry (the present is not symmetrical with the past, because the direction of the course is irreversible) is thus necessary for the existence of the individual. Perhaps, however, there is a perfect reversibility between individuation and temporality, time being always the time of a relation, which can only exist at the limit of an individual.[166]

The first sentence expresses the nature of this time, which is differential or asymmetric, and thermodynamic or "irreversible". The second sentence articulates the extent to which the individual *is* the time of transformation, which for crystallisation, exists at the limit of a portion of crystallised matter. Time is thus not something which is indifferent

[163] Ibid., 82.
[164] Ibid., 90.
[165] Ibid., 87.
[166] Simondon, G. (2013), 90.

to an individuation, but inseparable from it, hence: "there is a perfect reversibility between individuation and temporality".

That the present is not symmetrical with the past and that time is irreversible or unrepeatable may appear rather pedestrian observations regarding temporality. Indeed, in everyday experience we may feel the progression of time as a marking of difference with the past, and we surely know that reversing past events is the stuff of daydreams and science fiction. These aspects of time, however, mark a significant historical shift in the philosophical and scientific grasp of temporality.

Whilst everyday life appears to attest to direction and irreversibility in time, one of the great problems with dynamical theories is that direction in time is not assured - theoretically, change moves just as well forwards or backwards. Newton's *Principia,* for example, determined laws of causal succession but no direction in time (changes could move just as well "forwards" or "backwards"). Kant's first *Critique* (written during a period of high-Newtonianism), confronts the same problem, only with actual human life in question. Kant's resolution is to offer a transcendental "proof" where a dynamical one was lacking. Thus, a transcendental "principle of temporal sequence according to the law of causality", assures direction in time, legislating for human experience where Newton's mathematical physics could not.[167]

The thermodynamic discovery that entropy increases, and that perpetual motion machines are an impossibility (because some energy is always lost as entropy and unavailable for work in exchanges of energy, expressed by the second law of thermodynamics), led to what many consider proof of temporal irreversibility, or direction in time. Simondon's work, and particularly the section on crystallisation, is written in light of the science of thermodynamics, and the irreversibility of crystallisation plays a significant part in Simondon's engagement with crystallisation.

The significance of thermodynamic irreversibility is also representative of a broader distinction between Kant's transcendental philosophy and Simondon's work in *L'individuation*. Indeed, whatever might be said about the Newtonianism of the first *Critique,* the transcendental conditions of possibility for experience ought to be the

[167] Kant, I. (1998), 304-316.

fundamental conditions for the possibility of empirical science as well. The transcendental set out in the first *Critique* ought to lay out the necessary (thoughs not sufficient) conditions for natural science. In this way, Kant's transcendental might also explain gaps in Newton's project without problem - hence, providing a principle for temporal sequence. Simondon's text, on the contrary, does not attempt to deduce the conditions for the possibility of human experience, but instead begins with examples expressed according to scientific theories, drawing increasingly general ontological conclusions as he works through further examples. If the truth of the transcendental in first *Critique* rests on the truth of the deduction, the truth of *L'individuation* rests on the truth of the scientific theory (and Simondon's engagement with it) which informs the text. Philosophy legislates for Kant's transcendental, whilst natural science legislates for Simondon's transduction.

We are now able to draw together the conceptual elements we have just discussed. The limit as we have seen, has a double function. It distinguishes an individuating being from its milieu (which includes other individuating beings) and it is also the locus of the operation of information, or the command effected over the milieu. The crystalline individual consists merely of a limit; it is not an organised multiplicity, but the organis*ing* of a multiplicity. In this regard, we see that the individual is rather an individuating being, an operation of limiting and commanding. As an orientated transformation of energy, crystallising is an irreversible and asymmetric process - a unique event - and so long as the conditions of the milieu are correct (that there is available energy, substance and appropriate pressure) the individuation will endure indefinitely.

At this point we might wonder whether Simondon's example is too specific. There may be tension between the potentially limited applicability of crystallisation and the aim for a conception of transduction as a universal description of individuation. Oddly, Simondon seems to specify his example further than he might need to, arguing that a proper individuation involves periodic crystals, whilst aperiodic crystals are merely "imperfect individuals". His definition of an individual would thus be limited to structures which are identically repetitive. Thus,

> in nature, these imperfect individuals are often formed of a crystal around which an amorphous substance is fixed, in certain conditions (fog, snow). The conditions of formation of these imperfect individuals are comparable to conditions of supersaturation: one can initiate the formation of rain or snow in a saturated air by distributing crystals.[168]

Many of those far from equilibrium individuations or events considered significant in recent literature on philosophy and science may thus be rendered particular "imperfect" cases of transductive individuation. Equally, this may render living beings (excepting those which reproduce asexually, perhaps) "imperfect individuals". In this way, Erwin Schrödinger makes almost the opposite move, proposing that a proper crystalline-living analogy identifies living beings genetically as "aperiodic crystals", produced as aggregates "without the dull device of repetition".[169] In this sense, it may be more appropriate to determine crystallisations as particular by dint of their perfect periodicity. That said, as we will discuss later in this chapter, there may be a periodic core of life after all, if genes are considered substantial replicators and organisms their accidental vehicles, as Richard Dawkins has argued.[170]

Equally, however, we might argue almost the opposite, that the crystal is an analogy specific to life, and that there are many physical phenomena which are not analogous to crystallisation. Simondon certainly over generalises the example of crystallisation with the appellation "the physical individual". Whilst he tries to claim analogy between sub-atomic particles and crystals, many of the concepts which are maintained between crystallisation and life are lost.[171] The prioritisation of physical individuation may be regarded as an attempt to move beyond Bergson's vitalism (contradistinguished from matter and the physico-chemical sciences), and expand a broadly durational thinking

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[168] Simondon, G. (2014), 95 (footnote 17).
[169] Schrödinger, E. (1967), 60.
[170] In this sense, Dawkins identifies the repetitive aspect of life with crystals which repeat the same pattern indefinitely: "A crystal such as a diamond can be regarded as a single molecule, a proverbially stable one in this case, but also a very simple one since its internal atomic structure is endlessly repeated" (2006), 13.
[171] Isabelle Stengers argues in this way that whilst Simondon's discussion of crystallisation is appropriate, his discussion of quantum mechanics is too brief, discussing only de Broglie's theory (for its compatibility with his conception of transduction) and thus ignoring its more celebrated rival, the Copenhagen interpretation. The section in which this argument is made was retracted by Simondon from the first publication of *L'individuation*, and only included in *L'individu et sa genèse physico-biologique*, published in 1995.

becoming to include the non-living.[172] This would explain the inclusion of physical individuation and perhaps the paradigmatic status of crystallisation: such is Simondon's keenness to avoid vitalism that his prime example is physico-chemical.[173]

But whilst both of these criticisms are partially plausible, they overestimate the importance of the image of crystallisation at the expense of its conceptual results. Indeed, the concepts which we have discussed - limitation *qua* distinction, information as command and irreversibility and direction in time - are indeed generalisable. The example of crystallisation is far less important than what is generated from Simondon's analysis of it, and so too, the image of crystallisation should only be taken as an aid for the harder work of understanding the conceptualisation of the text.

Elementary multiplicity

The other difficulty which we must mention at this stage is the problematic status of crystalised and amorphous substance (whether liquid, solid or gas). Indeed, since the individual is the crystallising limit and not the amorphous or crystallised substance, this begs the question as to the status of the latter: are they individuals, and if not, what are they?

Simondon is oblique with regards to crystallised substance. Indeed, whilst he reflects at certain moments on the possible uniqueness of crystallised substance (whether it is properly individual rather than a mere instance of its crystalline class) and also on the possibility of grasping crystallised substance as a historical reflection of a past individuation, ultimately he concludes that the crystal is not an individual in what he

[172] In the third part of *Du mode,* Simondon thus writes that "Bergson made intuition the mode proper to the knowledge of coming-into-being; but one can generalize Bergson's method, without excluding a domain like matter from intuition, because it does not appear to present the dynamic aspects necessary for intuitive comprehension; in fact, intuition can apply co every domain where genesis occurs, because it follows the genesis of beings" (2012), 321-322 [242]. We will discuss the meaning and plausibility of intuition, as Simondon presents it here, in chapter four.

[173] The irony, of course, may be that Simondon's analysis remains so faithful to periodic crystallisation as to potentially exclude the possibility of an analogy with living beings. Other thinkers who have attempted a similar move incorporating physics and chemistry into a thinking of becoming - with and against Bergson - have emphasised precisely those self-organising systems which Simondon describes as "imperfect individuals (like snowflakes or whirlpools, for example). Deleuze is the lynchpin in this regard, though it has been primarily his attentive "scientific" readers who have developed his work in light of far-from-equilibrium and chaotic systems. See, for example, Prigogine, I. and Stengers, I. (1984), deLanda, M. (2013) and de Beistegui, M. (2005).

regards to the proper sense of the word.[174] That a crystal is not a transductive individual accords with our previous analysis, that transduction involves the transformation of available energy. In this way, transductive individuals are beings which transform available energy, but not those at thermodynamic equilibrium, whose becoming is mere degradation.

With regards to amorphous substance Simondon is clearer: it lacks organisation at the level of the whole, but its molecules might each be treated as transductive individuals. With this discussion he introduces his conception of *elementary multiplicity*, the final concept used to describe transductive individuation throughout the text.

Prior to crystallisation, the molecules in an amorphous substance move at speeds which depend in part on environmental or atmospheric conditions, but they do not relate to one another according to a regular, repetitive periodic structure. Molecules in an amorphous substance are incidentally unified, organised as a totality by an external boundary of some kind, but not by an immanent organisation like the molecular structure of a crystal. In this way, the amorphous substance "must be bounded by an envelope, and its surface can have properties belonging to the surface".[175] The informational operation of crystallisation is thus an organisation of the molecules of the amorphous substance, unifying them according to a crystalline structure. The molecules in a crystal are organised in a single repetitive structure whilst those in amorphous substances are not. Crystals are anisotropic - their magnitude varies when measured in different directions - whilst amorphous substance is isotropic. Unifying organisation is work of crystallisation, and it also clearly distinguishes the crystallising individual from the milieu.

At the very end of the section Simondon introduces the notion of "order of magnitude" or scale, arguing that individuation is a mediation between an elementary, or mollecular multiplicity and a molar unity: "individuation exists at an intermediary level between the order of magnitude of particular elements and that of the molar ensemble of the complete system."[176] An amorphous substance is a multiplicity of individuals indifferent to one another *qua* totality, whilst a crystal is (or *was*) an individuated being produced

[174] Simondon, G. (2013).
[175] Ibid., 95.
[176] Ibid., 97.

as the organisation of those molecules in an anisotropic unity. A crystalline individuation, then, is an organisational mediation between the molecular and the molar, between molecules distributed according to both amorphous and crystalline arrangement. The organisation or unity of an elementary multiplicity is a feature of every individuation in *L'individuation*, and it lays the foundation for the significant attention paid to the unity of vital multiplicities in the section on living beings.

We have thus added a final concept to describe transduction, elementary multiplicity, but we have not answered our question: is the amorphous substance an individual? Since molecules exist before crystallisation, this might pose a problem for Simondon's critique of atoms as substantial terms unaffected by their (accidental) relations. The simple answer is yes. The concluding comments on crystallisation, discussing molecular elementary multiplicity lead logically into the subsequent chapter of the text, which argues that atoms and molecules can be considered substantially relative. As we mentioned in the previous chapter, in light of Einstein's theory of relativity, Simondon argues that atoms are affected by relations to milieux as their mass increases with velocity.[177] In this way, atoms and subatomic particles are in keeping with Simondon's conception of substantial relation.

It is worth noting the movement of the text here, as its logical trajectory and rectifying practice are rarely acknowledged. In this way, *L'individuation* engages in a critical rectification of hylomorphism in chapter one, the analytical exposition of a new paradigm (crystallisation) which can adequately express individuation in chapter two, followed by a rectification of ancient atomism according to contemporary atomism in chapter three. The text thus moves through the "two ways according to which the individual can be approached" (atomism and hylomorphism), articulated in the very first line of *L'individuation*.[178] Transduction is thus not a wholesale refutation of either hylomorphism or atomism, but rather a rectification of both according to contemporary scientific theory.

We have now seen the sense in which the five concepts which make up transduction are derived from the example of crystallisation. The *limit* is constitutive of the individual, it

[177] Ibid., 126-7.
[178] Ibid., 23.

is both that which distinguishes the individual from what it is not - the milieu and its contents - but also the seat of the transformation of energy required for generation. *Information* is the operation which governs and orientates the transformation of energy such that it becomes work rather than entropy. In its simplest crystallising character, as we have argued, information is an operation of command. Crystallisation, then, involves a transformation of available energy which is commanded such that molecules of an amorphous substance are organised. As an energetic operation of organisation, individuation thus also exhibits a concomitant negentropic, directional and irreversible *temporality*. Finally, individuation is an organisation of an *elementary multiplicity* into an individuating unity. In the example of crystallisation, molecules in an amorphous arrangement are organised according to a crystalline structure at a higher order of magnitude.

These five concepts are maintained throughout Simondon's discussion of vital individuation. As we will see as we continue, however, they are equally developed or extended in order to accommodate the synchronous multiplicity of life.

3. Multiplicity and autonomy: limits of living individuation

Both the sections on physical and "vital" individuation, in *L'individuation,* work through the analysis of examples, and the latter does so in order to further develop transduction in order to grasp new and different problems presented by living beings. Like the rest of the text, too, the section on vital individuation attempts to think beings in so far as they are individuating rather than specific beings. Unlike the section on physical individuation, however, Simondon presents a great many distinctions between kinds or species of living being and numerous examples to demonstrate this.

The approach remains an attempt to grasp what is universal about the individuation of living beings, but in this section Simondon consciously discusses the variety of life in order to develop transduction accordingly. The "method", thus

> requires that one is not preoccupied, first of all, with hierarchically ordering the levels of vital systems, but that one distinguishes them in order to see which functional equivalences afford grasping vital reality across these different

> systems, developing the whole range of vital systems, instead of classifying in order to hierarchise.[179]

Instead of categorising living beings into genera and species - hierarchical classification - the approach is to try to find "functional equivalences" across the breadth of living beings. In order to derive these equivalences, however, the range of differences between the generation of living beings must first be articulated in order to demonstrate the range which transduction must grasp. Ultimately these equivalences constitute transduction as a universal description, extended in order to include living beings.

Although the section primarily engages with the sense in which transduction is more complex for living beings, developing its concepts accordingly, Simondon does offer a number of sketches for the continuity between physical and vital individuations. In this way, he offers the examples of the tobacco virus, single celled organisms and large protein molecules (the latter of which we will discuss in more detail later). Broadly, his point is that there are living beings which are as simple as crystallisation, but that it is only those more complex living beings which demand the development of transduction which takes up most of the section. The discussion of these transitionary beings - seemingly between the physical and the living - is decidedly hypothetical, but Simondon emphasises that these beings are very similar to his conceptualisation of crystallisation. Such beings thus exist as mere limits or membranes, like a crystallising being, and without an interior milieu regulated by operations of feedback or homeostasis, unlike more complex living beings. We might add, too, that each are relationally dependent on a milieu as a source of energy, over which they effect an informational command.

For the most part, though, the section on vital individuation engages with the sense in which transduction must be developed in order to describe the individuation of living beings. The concepts which we discussed previously are maintained but they are made more complex. In this way, vital individuation retains the temporal directionality and irreversibility of crystallisation - living beings ultimately transform energy, after all. The key difference is that many living beings exhibit both successive and simultaneous functions. Living beings individuate and grow successively (they may increase in size

[179] Simondon, G. (2013), 171.

and grow old, for example), but they also maintain their being through time (temperature is maintained and cells re-grow, for example). The development of successive *temporality* also has implications for the concept of *information*, since many beings regulate themselves or their interior milieu relative to an external milieu. The operation of *information* thus involves both command *and* control or regulation, whereas crystallising beings or atoms only enact commands. Finally, living beings are generated from other living beings, whilst many exist as unified multiplicities (collections of organs and cells, for example) and necessarily live in groups. *Elementary multiplicity* thus becomes a case of repetition and regulation, whilst the notion of the *limit* as a distinction between individual and milieu becomes one of autonomy and dependency.

Simultaneity and succession: vital temporality

One aspect of the temporal shift from physical to vital individuation is expressed by Simondon through the example of metazoa, beings necessarily made up of multiple cells which generate, die and regenerate. Metazoa live as unified regenerating multiplicities, dying and reproducing cells which must continue to do so in order to survive, or continue to exist. Thus, Simondon argues that although the cells of multicellular beings "are defined by well determined contours, they are not individuals" because they are both dependent on and, to some extent, under the control the unity of which they are elements.[180] Indeed, their activity "is only an element of the functional activity of the whole".[181] Individuality is thus accorded to the totality of cells, as each cell requires the whole in order to survive and to function.

Transduction is thus developed both in terms of the temporality of individuation and its relation to elementary multiplicity. With regards to time, multicellular living beings maintain a relatively stable state through the repetitive generation and regeneration of units of which they are constituted. A crystallising individual, on the contrary, does not maintain any simultaneity or repetitive unity of parts or elements, rather, it is merely a transforming limit that successively organises an amorphous substance. Crystallising is constituted as a limit not a totality; whilst it reorganises a molecular multiplicity, the

[180] Ibid., 191.
[181] Ibid.

individuating being proper is not a multiplicity. Only the individuated being or crystallised substance *after* individuation exists as a multiplicity.

Living beings individuate successively and irreversibly - growing and learning, for example - but many of them must also maintain or regulate themselves relative to their milieu. Thus, whilst living beings command, they also control or regulate. More complex living beings maintain themselves as an "internal milieu" relative to an "external milieu" (or as a self relative to an other). An internal milieu delimits an individual, distinguishing it from what it is not (the external milieu) and describes the multiple elements which are under the command of an individual, that is, the elementary multiplicity unified as an individual being. With this we note developments of the concepts we have been discussing (temporality, elementary multiplicity, limitation *qua* distinction from other beings, and information as command), which we will discuss as we continue. This description, however, is merely ideal. As Simondon demonstrates, it requires specification in order to deal with the reality of living beings.

Indeed, whilst some beings are more easily identified as unified multiplicities distinct from an exterior milieu, many live in groups or colonies which operate like an internal milieu relative to an external milieu. In short, it can be difficult to tell an individual apart from a group. Many species which appear in some respects to be individuals, also necessarily live in groups, and like the cells or organs of which living beings are constituted, many such beings depend on a group in order to live and survive. In such cases, individuality must be accorded to the group:

> The only concrete reality is vital unity, which in certain cases can be reduced to one being and in other cases corresponds to a very differentiated group of multiple beings.[182]

The problem, then, is grasping the level at which individuality occurs. All multicellular beings are multiplicities; the difficulty is determining the level at which they are a unified multiplicity which is also independent from other beings.

[182] Ibid., 157. The first sentence is a passage from the main text and the following sentence its corresponding footnote.

Simondon thus gives an example (in a footnote to the passage above): "Thus, termites…act almost as a unique organism, working in a group."[183] Indeed, termites are morphologically and functionally divided according to functions within a nest: primarily, queen, king, soldier and worker. Queen and king termites copulate, and the former lays eggs; solders defend the nest, and workers construct the nest, collect food and groom and feed all of the others within the nest. Both soldiers and workers are sterile, and thus reproduction is entirely fulfilled by queen and king. Like the cell of a multicellular organism, then, soldier and worker termites are dependent for their existence on a group which does not, in turn, depend on them (as single organisms) for its existence.

Resolving this problem takes up most of the section on vital individuation (the longest of the text). It is a difficult section, divided into sub-sections which often mark abrupt shifts in problems and themes, whilst it is expressed in obscure and sometimes elliptical language. Our contention, however, is that there is a logical thread which runs through the section, developing the concepts we discussed regarding crystallisation. Indeed, whilst some readers have acknowledged the concepts of independence, multiplicity and homeostasis, they fail to recognise and examine the argument that develops throughout the section, which is crucial to understanding the conclusion which Simondon arrives at.[184] In turn, grasping the resolution in this section is the only way to properly grasp the stakes of Simondon's position.

In what follows, then, we attempt to articulate this argumentative sequence according to the two primary modes of this problem and the two respective resolutions in Simondon's text. With this in hand, we then discuss remaining issues in light of contemporary biological philosophy.

Growth and reproduction: dependence and independence

Individual living beings are unified multiplicities which must be distinguished from other beings, according to Simondon. As individuals distinct from a group they are also

[183] Ibid.
[184] Andrea Bardin is the closest reader of this section and unique in his recognition of some of the problems raised therein, however, he does not grasp the systematicity and development of Simondon's argument, nor does he pursue its problems to their limit as we attempt to. Bardin, A. (2015), 69-87. See also, Chabot, P. (2003) 89-95.

individuating, as their elements multiply, die and regenerate. Unlike crystallising beings, living beings both reproduce or maintain themselves simultaneously through generative repetition, but also produce new individuals separate from themselves. Simondon expresses this as the genetic distinction between growth and reproduction, or the distinction between the generation of beings which are dependent on (or subsumed under) the being from which they were generated and those which are independent from it. Growth is thus sub-individual generation whilst reproduction is individuation proper.

For many species of living being this distinction may be relatively uncomplicated. Growth involves cellular reproduction, which regenerates organs and parts which are commanded as a unity. Reproduction produces a separate unified multiplicity, or a new individual. For many other beings, however, things are different. For those living beings which reproduce by binary fission (cell division), there is no difference between growth and reproduction. Cells grow, but once they reach a certain size, they divide. Equally, as Simondon notes, colonial coelenterates may produce new parts which live attached to the colony, like the cells of a metazoan.[185] Simondon's conclusion here is rather odd, as he proposes that amoeba and many infusorians (single celled organisms which reproduce by binary fission) "are not, properly speaking, genuine individuals".[186] Rather than recognising that these beings are almost entirely successive individuating beings, much like crystallisations, he proposes that they are sub-individual.[187]

More conclusive is Simondon's discussion of fission at the level of an individual or colony, whereby a being breaks away and continues to live apart. Thus, for example, certain species of sea cucumber and worm may be divided and both parts continue to live. So too, many coelenterates[188] live as colonial individuals (with divisions of labour and specialisation much like termites), but they may also form a new colony if a part is broken off. Equally, coelenterates and certain other multicellular beings can reproduce by budding (asexual reproduction whereby a new being is produced from an anatomical

[185] Ibid., 188.
[186] Ibid., 168.
[187] No reason is given for the pre- or sub-individual status of such beings, but the implication is that this results from the fact that for them, growth and reproduction are indistinct, which is precisely the nature of crystallisation.
[188] Such as corals, hydras, jellyfish, Portuguese men-of-war, sea anemones, sea pens, sea whips, and sea fans.

part of an organism). Beings produced by budding may either remain part of an initial colony, or they may break away to form a new and independent colony.

Thus, one of the factors distinguishing reproduction from growth is the ability to live independently from an initial group or colony from which it was generated. Simondon writes thus, that

> the criterion that permits recognising real individuality, here, is not material, spatial, liaison or separation of beings in a society or colony, but the possibility of life apart, of migration outside of the first biological unity.[189]

The generation of beings which can live independently from the vital group from which they were initially generated is reproduction, and these beings can be said to be individuals according to this criterion (which, as we will see in a moment, is necessary but not sufficient).

The capacity to live apart from an initial biological unity is a successful criterion to the extent that it distinguishes growth from reproduction, or the generation of sub-individuals from individuals, and it also goes some way to determining individuality as autonomy from groups. One can see, too, the sense in which this offers a way to reformulate transduction for life. In this situation, transduction still involves an irreversible and negentropic transformation of available energy, whilst individuation is still successive. As a transformation of energy from the milieu, this is also a mode of transductive or substantial relation (which we discussed at length in chapter one), to the extent that an individual is dependent on and altered by its relation to a milieu. But the capacity for life apart develops another mode of the relation, namely, as the limit which differentiates an individual from its milieu (which includes other beings). Elementary multiplicity is more complex when it comes to living beings, which forces a development of the concept of the limit *qua* distinction. Thus, independence or the capacity to life apart from an initial vital group develops the notion of limitation according to the level at which vital individuality exists relative to sub-individual and meta-individual multiplicity. It is necessary for all but the simplest vital individuals, which do not live as multiplicities.

[189] Simondon, G. (2013), 168.

The capacity for life apart from an initial vital group also affords an interesting distinction between anatomical difference and independence proper. We thus note in the passage above that the capacity for life apart is "not material, spatial, liaison or separation". In this way, Simondon proposes that even mammalian young, which are highly anatomically differentiated after reproduction, cannot be considered individuals because they rely entirely on the mother for nutrients. Thus, whilst mammalian young have an "extremely precocious detachment" from the mother, this is "compensated by a relation of exteriority between young and parent, similar to that of a parasite, internal first of all, then external, by gestation, then by suckling".[190] Such beings are thus anatomically separate, but have an energetic (nutritive) dependency on their mother. Until young are capable of living apart, they exist like parasites, drawing energy from the mother, which acts as a host, receiving no benefit in return (in this regard, at least).

Ultimately, whilst the capacity for life apart is necessary for distinguishing reproduction from growth (which is in turn necessary for determining individuation), it is not sufficient for distinguishing individuals from one another. As a criterion, it determines reproduction or individuation, but broader issues regarding dependence and independence remain. Crucially, even if some living beings have the capacity for total independence from an initial vital group, no species of being is entirely independent from other beings. Fundamentally, living beings depend for their existence on a milieu which is populated and regulated by other beings. They may have the capacity for life apart from an initial group from which they were generated, but none has an absolute capacity for life apart or for total independence. Living beings necessarily depend on one another for existence. All living beings require particular environmental conditions which are maintained in part by the specific population of an area, whilst all living beings - except for the vast majority of plants - derive energy from other living beings. Living beings are necessarily interconnected and dependent on one another in a wider ecology.

Taking a step back for a moment, it should come as no surprise that Simondon argues that individuals are dependent on one another. Indeed, his critique of substance (a "thing that exists in such a way that it does not depend on anything else for its

[190] Ibid., 173.

existence") was to argue precisely that beings depend on the milieu to which they relate. Nor is it unexpected that Simondon would be keen to find criteria which distinguish beings from one another, as his interest is individuation. Nonetheless, negotiating between dependency on a milieu and individual distinction is conceptually demanding.

Before we discuss Simondon's final criterion for distinction between individuals, we might note first that attempting to grasp the individuality of beings in a wider ecology sets him apart from Bergson, who in *Creative Evolution* consistently emphasises the incompleteness of individuality and individuation, and the continuity of beings with one another. In the broadest terms, Simondon accepts some continuity between beings - they are dependent on one another for their individuation, or their being - but equally attempts to distinguish them from one another as separate individuals. Simondon's text might even be read as a response to Bergson's. Both accept that there might be degrees of individuality, and use many of the same examples (such as the division of hydra and worms, for example),[191] but whilst Bergson poses a succession of rhetorical questions about the incompleteness of individuality, Simondon appears to attempt answers to them. In this way, Bergson suggests that it is impossible to determine whether a living being is one organism or many cells, that sexual reproduction and (non-binary) fission pose potentially irresolvable problems for grasping individuality[192] and that germinal cells divide beings within themselves, and Simondon offers a response to each.

Ultimately, the reason that these questions remain rhetorical for Bergson is because he argues that vital unity exists as a continuous whole which incorporates every living being, in short, as an *élan vital*. Indeed, whilst Bergson repeatedly asks how one might delimit a living individual when living beings are dependent on and interconnected with one another, his position is nonetheless unequivocal:

> This life common to all the living undoubtedly presents many gaps and incoherences, and again it is not so mathematically *one* that it cannot allow each

[191] Bergson, H. (2018 [1944]), 12-14 [16-7].
[192] Ibid, VI; 13-14 [xx; 17].

> being to individualise [*s'individualiser*] to a certain degree. But it forms a single whole, nonetheless.[193]

Whilst beings may be individualised to an extent, then, ultimately they are continuous with the "single whole", the *élan vital*. In this regard, individuality is pitched at the level of the whole of life. Living beings and their parts are only partially distinct from one another, but more profoundly they are an interconnected developing whole, continuous with one another as the *élan vital.*

Simondon does not directly criticise Bergson's position in this regard, but his position represents a conscious departure from it nonetheless.[194] Indeed, whilst individuals are not absolutely distinct, for Simondon, he makes a significant attempt to develop criteria for their distinction from one another. Equally, whilst he has a conception of a general source of creative energy - preindividuality, which we will discuss in the following chapter - he does not argue that it "forms a single whole". Rather, he maintains that individuations happen as mediations between orders of magnitude. Instead of expressing the interconnectedness of living beings as an indistinction which points towards a higher order unity - like the *élan vital* - Simondon endeavours to distinguish living beings from one another whilst retaining the sense in which they also depend on one another through a transductive relation.

Command and control: "regimes of information" and homeostasis

According to Simondon, then, new individuals may be distinguished from the being or group from which they arose by a capacity for life apart, which also serves to distinguish between growth and reproduction. But this is not a sufficient criterion, because, as we have briefly discussed, many living beings are never independent from vital groups from which they were produced, whilst every living being is dependent on

[193] Ibid., 43 [50] (translation modified).
[194] The only criticism of Bergson in this section is Simondon's argument that individuation is both continuous and discontinuous. This is clearly resonant of the criticism Bachelard (1936) levels at Bergson, namely, excluding discontinuity; a debate that has been recently revived by contemporary interest in Bergson and the disagreement between Badiou and Deleuze. It is worth noting that the continuity of the *élan vital* may not exclude any discontinuity including that of generation, as contemporary readers have been at pains to demonstrate (Ansell Pearson, K. (2002), 74; 87-9; Mullarkey, J. (1999), 12). Furthermore, since Simondon's critique is not levelled at the continuity of the *élan vital* whilst Bergson's expression of creation may include discontinuity as a mode of the continuity of the *élan vital,* Simondon's position may not be so different from that of Bergson after all.

a milieu which is made up of other beings. Thus, Simondon offers a final criterion for distinction or independence, namely, the capacity for command and control, or the capacity to act and receive and respond to information signals autonomous from other beings. In this way, whilst beings might be dependent on one another - as sources of energy, for example - they are distinct according to their capacity to command organs and parts of their whole being and according to the capacity to receive and respond to stimuli. This is particularly clear when it comes to beings such as mammals, many of which must live amongst others, relying on the group for survival, but nonetheless have developed central nervous systems which distinguish each being from the other.

This amounts to development of both the concept of information and that of the limit *qua* distinction from other beings. Unlike crystallising beings or atoms, many living beings have the capacity both to command - transforming energy in order to move a limb, for example - but also to regulate behaviour in order to achieve and maintain a goal relative to changes in stimuli received from the milieu. A crystal commands available energy in order to reorganise molecules, but it cannot modify its command in light of a changing environment. Simply put, many living beings are capable of homeostasis or self-regulation whilst physical individuals are not; living individuals have informational capacities of both command and control, whilst physical individuals can only effect commands.[195]

One of the clearest distinctions between physical and vital individuation, then, is that whilst (most) living beings are capable of receiving stimuli from an external milieu and regulating themselves or their "internal milieu", physical individuals and the simplest living beings are merely a limit or "membrane" which can only command (or attempt to).[196] This vital capacity is a homeostatic operation of feedback or "recurrent causality":

[195] "The homeostasis of the living being does not exist for the purely physical being, because homeostasis relates [*se rapporte*] to external conditions of transduction, thanks to which the being uses the equivalence of exterior conditions as guarantees of its stability and its internal transduction." Ibid., 161.
[196] "The simplest organism…is that which has no mediating interior milieu, but only an absolute interior and exterior. For this organism, the characteristic polarity of life is at the level of the membrane; it is at this place that life essentially exists as an aspect of a dynamic topology which itself maintains the metastability by which it exists." Simondon, G. (2013), 225.

> There is, in this case, a centre from which a being stores past information and by means of which it commands, surveys, inhibits or facilitates ("control", in the English vocabulary) the passage of a centripetal information to a centrifugal reaction.[197]

A being receives "centripetal information", which is used in order to act to achieve a goal. Command describes the "centrifugal reaction", or the action of a being (inhibiting or facilitating) in response to information and in order to achieve a goal. Control describes the ability as a whole, which according to Simondon, determines the limits of a vital individual.[198] Crystallisation, in these terms, is merely a centrifugal information - it cannot act on received stimuli.

The capacity to receive and respond to stimuli from the milieu - the capacity for control or regulation - produces what Simondon calls a "regime of information", which constitutes individual unity as those elements which are under the command and control of a living being. [199] Plants, for example, enact commands in so far as they grow and move parts, but they are also able to enact operations of control relative to environmental conditions, responding to stimuli in order to achieve a goal. Thus, what "constitutes the unity and assures the individuality of a plant", is its capacity for control, that is, receipt and response to stimuli in order to achieve a goal.[200] For a plant, this ability affords "autoregulation of exchanges in terms of needs, the opening and closing of pores, sweating, the movements of sap."[201] Plants open or close stomata (pores) for gas exchange - drawing in Carbon Dioxide for photosynthesis and releasing Oxygen in respiration - or in order to control water loss. Thus, they react to changing environmental conditions in order to achieve a goal: in windy, hot or dry conditions stomata may be closed in order to conserve water. Behaviour is thus regulated in response to stimuli from the milieu in order to maintain existence as required for survival and reproduction.

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[197] Ibid., 191.
[198] "The individual is characterised as the unity of an information system; when a point of the whole receives an excitation, this information will be reflected in the organism and return under the form of a motor reflex or more or less generalised secretion…this reflex is placed under the dependency of a centre, if the whole is individualised; this centre creates facilitation or inhibition." Ibid., 190.
[199] Ibid., 190-204.
[200] Ibid., 192
[201] Ibid.

A regime of information thus describes the elements unified under the control of a living being, which may be used to enact various vital operations or receive signals from the milieu, relative to which a being can regulate itself. But a regime of information also distinguishes a being from others, according to Simondon. The unity of command and control describes the extent and limits of an individual, distinguishing beings which may be otherwise dependent on one another - such as mammalian young on their mother. Even dependent beings, such as those in symbiotic or parasitic relationships, may be distinguished according to a regime of information. Simondon exemplifies the symbiotic relationship between green algae and fungi, commonly called lichen. The algae provides energy for the fungi through photosynthesis (of which all fungi are incapable), whilst the fungi provides a support for the algae, retaining water and humidity the latter requires for life.[202] Due to the criterion of the regime of information, however, the fungi and algae can be distinguished from one another. The fungi is exterior milieu for the algae, and vice versa.[203] Parasitic relationships are similar, such that the parasite may depend almost entirely on a host, for both energy and reproduction, but if both have different regimes of information, the two may be distinguished.[204]

This also makes possible a definition of communication as the receipt of meaningful stimuli from the milieu in a regime of information. Stimuli must be meaningful, to the extent that they provoke registration or reaction, broadly conceived (we will discuss Simondon's definition of information as meaning in the following chapter). Equally, stimuli must be received from the exterior milieu, that is, from something other than a being itself (the example of a being touching itself - auto-affection - would be thus considered regulation rather than communication). However mutually dependent and integrated living beings might be in an ecology, they are differentiated or individualised by their receipt and response to stimuli. This also provides a means to distinguish clonal

[202] Ibid., 198.
[203] Ibid., 199.
[204] Simondon exemplifies sacullina, an extraordinary parasitic species of barnacle which is hosted by crabs. Sacullina derive energy from their hosts and release chemical hormones which render the crab infertile and alter their morphology and behaviour - a male crab may resemble a female and execute their mating dance. Crabs infected with male and female sacullina undertake normal mating behaviours, finding other infected crabs with which they fertilise sacullina eggs. Crabs carrying fertilised eggs then nurture them as if they were of their own species. Finally, sacullina larvae are released by the crab, and the cycle continues.

beings - like populations of trees, for example - which may appear to be a single continuous individual, where each tree is an aspect of the "growth" of a single individual. Communication amongst trees and plants more generally has recently begun to be recognised. Indeed, many such beings rely on communication with one another, through chemical signals, for example, which may be received as a meaningful stimulus alerting danger and initiating a regulatory response. One could thus defend a conception of a clonal multiplicity of individuals with distinct regimes of information.[205]

With the distinction between growth and reproduction and the concept of regimes of information in hand, we can return to our earlier reflections on the necessary dependency of living beings on one another. It was necessary to distinguish reproduction from growth in order to distinguish between the perpetuation of an already existing being and the creation of a new being. But whilst this distinguished beings from their generative source, it did not distinguish beings from the milieu, or indeed, other beings. Informational autonomy is thus necessary as a further criterion for individuality once perspective shifts to a wider ecology, because no being has the capacity for independence from, or life apart from a milieu.

As we have said, any being requires appropriate environmental conditions - those which will not lead to its destruction[206] - and those which Simondon describes as transductive individuals require a supply of available energy in order to continue to exist. Living beings are necessarily dependent on a vast array of other living beings which, in part, constitute milieux. Simondon recognises that living beings require other living beings to generate conditions necessary for life, even if he somewhat understates it:

> The independence of individuals relative to one another is, moreover, rare and almost impossible: even when individuals do not have an anatomical link between them, the influence of the milieu which surrounds them remains, and,

[205] See, for example, Wohlleben, P. (2016) and Mancuso, S. and Viola, A. (2015), 90-122.
[206] This is a truism, of course, but it highlights the relationality of Simondon's position. This is clearly expressed by phases of matter, which demonstrate that beings depend on systemic conditions.

> amongst these influences are those which arise from other individuals, components of the milieu.[207]

He is wrong, of course, that the independence of individuals is "rare", rather, it is simply impossible. The milieu, as Simondon acknowledges, is a condition for the possibility of individuation, and for living beings milieux are also necessarily made up of other living beings.

Living beings are multiplicities, made up of parts like cells, but they are also dependent on and interconnected with groups at higher orders of magnitude. To avoid the interconnectedness of life leading to unity at the level of the whole (as we saw with regards to Bergson) Simondon introduces the criterion of informational autonomy. In many respects this is a successful continuation of his position, which pitches individuation between orders of magnitude. Regulatory autonomy or homeostatic self-identity is also in keeping with Simondon's demand for an individual which exists at a mid-level, between an elementary multiplicity and a higher organisation. Each part of a living being is multiple whilst the higher level "molar" organisation is the homeostatic range within which the being is maintained. Transduction, in this sense, involves mediating between parts and the homeostatic range - there is never full resolution, but rather continued individuation.

This resolves a problem Simondon identifies with substance, to the extent that it is either infinitely great, for Spinoza, or infinitely small, for Leibniz.[208] Neither infinitely great nor infinitely small are substantially relative, as in each case a substance relates only to itself. Homeostatic autonomy is at once able to valorise and incorporate necessary relationality into the transductive picture, but also distinguish living beings as individuals from other living beings. It produces a criterion for individuality which is necessarily relative, as a transformation or transduction of energy, and through the informational orientation of that same operation, distinct from other beings.

We might note, too, that the concepts which we discussed earlier have been developed but not broken with. Elementary multiplicity is retained, but takes on a new problematic aspect as many vital individuations involve the maintenance of a

[207] Ibid., 194.
[208] Simondon, G. (2013), 65.

multiplicity as a unity through time. Temporality takes on the new dimension of synchronicity or simultaneity *as* a being which exists as a unified multiplicity of repetitions (the growth and regrowth of cells, for example). These repetitions are differential, though, and the temporality of vital individuation remains successive nonetheless, including both directionality and irreversibility. Information remains an operation of command, as we have discussed, but with the multiplicity of individuation and the synchronicity of time it takes on a new sense, that of control or regulation (or governance in Maxwell's terminology). Finally, the notion of the limit as a distinction between an individuating being and its milieu is maintained but takes on a great deal more work as it must distinguish more complex and subtle unities.

Whilst Simondon's argument is in many ways successful, then, we might make a number of criticisms of his articulation of vital individuation, drawing on more recent work from the philosophy of biology.

Individuals at any scale?

First, Simondon's criterion of command and control may not be enough to limit the determination of individuality to a single scale. Indeed, contrary to Simondon's position, various thinkers have argued that individuals can be determined at various scales of life - thus, a cell, an organism and a species could all be individuals at the same time.[209] In particular, thinkers have emphasised that biological species should be considered to be individuals, but they also argue that these species-individuals are made up of individuals. Individuality would therefore exist at different scales simultaneously. A species like *homo sapiens,* then, is an individual made of organisms which are equally individual. Thus, *homo sapiens* is an individual constituted of parts which are individuals in the same way that the parts of a species-individual are also constituted of parts (like cells) which are individuals. Each part at any level can be considered individual so long as it fulfils various criteria.

The argument is primarily articulated as a resolution to taxonomic problems by changing the status of biological species from classes or "natural kinds" to individuals. These theorists argue in this way that species are not abstract and instantiable

[209] See, for example, Ghiselin, M. (1997); Hull, D. (1978).

(classes), but rather concrete and un-instantiable (individuals).[210] Thus, instances of a class like "organism" can be given, for example, but instances of an individual (like Socrates) cannot be given. These thinkers argue that biological species cannot be reduced to essences, then, because there are always exceptional beings which elude a specific essence, or which cannot be considered instances of one. Species are thus not considered classes but historical, concrete individual totalities, constituted of parts which are irreducible to essential descriptions, which are becoming or trans-temporal.

We do not intend a full discussion of the species-individual concept, as we can see already what is important regarding Simondon's position. If individuals coexist at various different levels, if both a species and its constituents (organisms, organs, cells) can be considered individuals, then Simondon's various criteria may be unnecessary, and his conclusion in error.

Above all, perhaps, it serves to draw attention to Simondon's informational criterion for individuation. Indeed, whilst species-individuals are determined according to logical criteria, such that any unified, non-instantiable being could be individual - a brick, *this* portion of brick which has been broken off; a cell, half a cell, a quarter of a cell, and so on. Simondon's position, on the contrary, requires that there is command, and in some cases control over generation. An individuation is thus delimited as an operation of command, and for many living beings, as the capacity for receipt and response to signals. Neither an organ nor a species have such capacities. For the species-individual concept, autonomy or informational independence is of no significance for determining individuality. Indeed, this position accepts individuality at any level, regardless of dependence or independence; and in this way it is like an inversion of Bergson's position, which only finds individuality at the level of the whole.

For Bergson, any attempt to delimit an individual - to definitively "cut it out" of the continuity of the *élan vital*- fails because beings are durationally interconnected. Simondon, on the contrary, argues that individuals are divided from one another (or indeed, divide themselves) as regimes of information. He does not argue that individuality does not exist at various levels, or that individuals do not exist as parts of others. In this way, he hypothesises that physical individuals may be considered

[210] Ghiselin, M. (1997).

constituents of vital individuals - both considered individuating, rather than individuated. Thus, he argues that "the individuation of systems like the large molecules of organic chemistry" may describe the continuity between the physical and the vital, and that they are "sufficiently complex for variable regimes of reception of information to exist".[211] Such molecules may thus be informationally distinct from the being which they constitute, but nonetheless dependent both on the being as a whole as well as its milieu.

There is, nonetheless, a sense in which the species-individual argument is similar to Simondon's own discussion of growth and reproduction. According to the species-individual concept, what Simondon calls growth - the continued individuation or becoming of the same individual - is pitched at the level of the species, whilst reproduction happens when a new species arises. One could, of course, respond in the same way that Simondon does, with an informational criterion. Thus, whilst species may be considered living unities, they are not individual, as they are not regimes of information. At this point, however, we might argue that Simondon has changed the terms of individuality in order that it requires informational autonomy. This may be considered a further specification of "transductive individuation", such that it refers to negentropic beings but also those which are informationally unified. This is significant because individuality considered as command and control is a continuous operation of self-distinction, such that the very being of an individual involves its distinction from others (even communication, as we have discussed). A species individual, on the other hand, only actualises as distinct from other beings when its parts reproduce. Parts are independent from the whole and they only determine themselves as its constituent parts if and when they reproduce; otherwise, organisms *of* a species are so merely by dint of an observer.

Substantial genes, accidental organisms?

If we return now to "the individuation of systems like the large molecules of organic chemistry",[212] another criticism might be levelled at Simondon's argument, namely, his substantial conception of relation in light of evolution by natural selection and genetic

[211] Simondon, G. (2013), 151.
[212] Simondon, G. (2013), 151.

theory. Evolution by natural selection is effectively entirely absent from *L'individuation*, and indeed, the moment at which Simondon reflects on Darwin and Lamarck, the discussion focusses only on the psychic implications of adaptation.[213] Equally, whilst he engages in a brief discussion of August Weismann's theory of the germ-plasm, concluding quickly that Étienne Rabaud's Lamarckian counter-theory of "hereditary substance" is superior, he fails to recognise that the stakes of the difference between Weismann and Rabaud are different theories of evolution.[214]

It is easy to see why Simondon would criticise Weismann: the theory of the germ-plasm seems in direct contradiction of Simondon's own theory of substantial relation. For Weismann, whilst the soma carries out ordinary bodily functions the germ is the source of heritable characteristics. Crucially, unlike the soma, the germ cannot be altered by its relation to an environment. Weismann's concept of the germ cell is thus precisely what Simondon rejects in substantialism and atomism, namely, that it is a term or seat for relation which cannot be altered by that relation. In this respect, what can be affected or altered by relation - somatic cells - are mere accidents of germinal substance.

Ostensibly, Simondon's response to Weismann comes through an adherence to Étienne Rabaud's theory of "hereditary substance". As Simondon reads it, Rabaud contends that both germ and soma are required for reproduction, and both are affected by their relation to an environment.[215] But whilst Simondon is broadly correct, he does not recognise that the keystone of this distinction is heredity: whether or not acquired characteristics can be passed on to progeny. Rather, he presents the problem as if it referred only to an individual being; that is, whether the whole being is affected relative to the environment, or whether there is a substantial or germinal core which remains the same throughout life, or which cannot be affected.

In this way, Simondon fundamentally fails to grasp what is at stake in the difference between Weismann and Rabaud: ultimately, the difference between neo-Darwinism and neo-Lamarckism. His summary of Weismann's germ-plasm theory is not inaccurate but insufficient - he does not acknowledge that it rests or falls on whether the germ can

[213] Ibid., 211. It is odd, to say the least, that the two mentions of Darwin in *L'individuation* are discussions of psychic individuation.
[214] Rabaud, E. (1932); Weismann, A. (1839).
[215] Rabaud, E. (1932).

change between generations. Instead, he presents the difference between the theories of the germ-plasm and hereditary substance as if they pertain to whether the individual is either produced by a determinant but unaffected germ, or whether the whole being may be affected by relation. He does not recognise that the disagreement comes down to whether acquired characteristics are passed on through reproduction. Thus, it might be tempting to propose that Simondon is broadly Lamarckian to the extent that a being would be fully affected by its relation to the milieu. However, Simondon does not argue that characteristics acquired through relation to a milieu can be passed on to progeny through reproduction. His position thus cannot be labelled Lamarckian because he does engage with the fundamental question of Lamarck*ism*, namely, heredity.[216]

The absence of evolution by natural selection from *L'individuation* is both a surprising and significant oversight. Indeed, considering Simondon's attention to other recent developments within the natural sciences, the omission is especially unexpected. As Barthélémy notes, the 1953 discovery of the double helix structure of DNA may have been fairly close to the period in which *L'individuation* was written, but the theory of evolution by natural selection had been established almost one hundred years previously, whilst Weismann's theory had been widely accepted for around fifty.[217]

History has not been kind to Simondon's critique of substance, as Weismann's argument for the impermeableness of the germ cell - now known as the "Weismann barrier" - has gained practically universal acceptance. There is a powerful sense in which a conception of substance, as a seat for relations which is unaffected by them, remains at the heart of the biological understanding of both individuals and heredity.

Perhaps the most famous recent development of this view is found in *The Selfish Gene*, in which Richard Dawkins argues that genes (or "cistrons") are the primary unit of natural selection, whilst organisms are their mere "vehicles".[218] The argument runs as follows: in order for something to be selected it must be replicated; as organisms are exist for only one generation, they are not replicated; thus, organisms are not units of

[216] Ann Fagot-Largeault argues, for example, that Simondon "was fundamentally a Lamarckian, like all of French biology at the time, one must say. He had never come to terms with Darwin, in fact he hadn't even tried. That in itself is a problem, because it casts doubt on his metaphysical intuitions: his metaphysical intuitions remained Lamarckian." Fagot-Largeault, A. and Bardini, T. (2014), 146.
[217] Barthélémy, J-H. (2015), 17.
[218] Dawkins, R. (2006), 32-33.

natural selection. In this sense, organisms and species change as they are reproduced, but genes do not. Genes are "replicators"[219] which are copied through generations of organisms. A single gene survives a generation, of course, but more profoundly, a gene survives as a lineage of copies. As a lineage of copies or replicas, genes may survive indefinitely. Finally, the function and aim of genes, according to Dawkins, is replication, and they accommodate whatever it takes in order to replicate themselves. Thus, both "selfish" and "altruistic" behaviours at the level or organisms are attempts to achieve the same ("selfish") goal: replication of the genes for which they are the vehicle.

Dawkins' theory might appear utterly at odds with Simondon's to the extent that genes remain unchanged through reproduction, and the historical success of the Weismann barrier may thus be considered, in turn, a failure of Simondon's critique of substance. To a certain extent this is undeniable. There remains a strong substantial component to contemporary genetic theory, beginning with Darwin and crystallised by Weismann's theory. In this regard, then, Dawkins demonstrates the sense in which genes are unaffected by their relations, or their vehicular accidents.

However, Dawkins' argument equally demonstrates the extent to which genes depend on relations to other genes within an organism, and at a second degree, as it were, between organisms and environments. Indeed, whilst organisms are not the units of natural selection because they are not replicated, they make gene replication possible nonetheless. If an organism does not reproduce, the genes for which it is the vehicle cannot be replicated. The success of genes is thus tied to the reproductive success of their vehicles. Genes are similarly dependent on one another to the extent that their multiple or combined expression is fundamental to both the constitution and hence the reproductive success of an organism. For the same reason, genes are dependent on relations between their vehicle organism and its milieu (composed of other organisms, atmocpheric and meteorological conditions). If an organism cannot reproduce because it perishes due to its incapacity for survival in its environment, its genes are not replicated. Indeed, the dependence of a gene on organisms and relations between organisms explains the thesis of Dawkins text: apparently altruistic behaviour in relationships between organisms is really "selfish", as genes merely use other

[219] Ibid., 12-20.

organisms as means to their replicating ends. Whether relations appear altruistic or selfish at the level of organisms, they are always selfish at the level of genes.

Genes are thus substantial to the extent that they are unalterable terms for relations, but they are also radically dependent on one another in the constitution of their organismic vehicles, and on relations between organisms, populations and climates. In this sense, genes are unaltered by their relations - which are accidental relative to the gene, though not to an organism - except, crucially, to the extent that genes rely on the reproductive success of their vehicles. Indeed, a gene is not a being "that exists in such a way that it does not depend on anything else for its existence", rather, they are entirely dependent on their vehicles for existence. In this regard, then, Simondon's critique of substance is correct. Equally, whilst the Weismann barrier does offer a significant atomic or substantial rejoinder to Simondon's position, it must also be noted that gene expression is necessarily alterable relative to conditions of the milieu, even if genes as replicating lineages are not. To a very large extent, living beings exist as substantial or transductive relations to their milieux.

Conclusion

If we return now to Simondon's conception of *paradigmatism* and analogy, which we discussed at the beginning of this chapter, we are now better able to appraise its success. We saw that Simondon's analogy requires significant conceptual work in order to produce the key concepts for transduction, namely, elementary multiplicity, limitation as distinction, information as command, and directional, irreversible temporality. In this sense, the example of crystallisation provided these concepts after the work of analysis, a far more complex result than the "the simplest image of the transductive operation"[220] supplied in the introduction and so often taken as the extent of transduction.

We also ought to recognise that the transductive analogy throughout *L'individuation* is rather more complicated than Simondon's text sometimes suggests. Whilst he presents his paradigmatic method as an analogy between an operation derived from a prime example or paradigm and other operations, it is not clear that *L'individuation* fulfils this

[220] Simondon, G. (2013), 32.

aim. Indeed, we have seen that Simondon's paradigm, crystallisation, is far more complex than that with which he would compare it with in Plato's *Sophist*. The analogy of luring, enacted by sophist and fisherman alike does not require anything like the same kind of conceptual analysis that transduction demands, and more significantly, Plato's analogy is not developed in order to apply to different beings. A better comparison, in this regard, might be with the great cybernetic operational analogy, homeostasis - control or regulation according to feedback. Again, however, homeostasis is complete from the beginning; it is not developed in order to apply to further different kinds of being. Rather, as a concept, homeostasis is accomplished in its first expression (perhaps in Maxwell's text) after which, each time it is used in analysis or discovered in a new domain it is *re*applied. Although Simondon presents his conception of analogy as the same as these two, then, his transductive analogy requires a series of problems and resolutions (far more complex than those of homeostasis or of the angler and the sophist) in order to produce a basic operation of transduction.

The argument in *L'individuation* is better grasped as the development of transduction as an operation which accommodates degrees of complexity - stretching from physical and simple living being to more complex living beings. In this light, the text works through the conceptual production of the operation which might serve as the basis for analogy rather than the application of the analogy. As we have seen, *L'individuation* does not engage in a merely repetitive application of the simple image of crystallisation to other beings; instead, it works to produce the operation.

At this point we have covered the pre-history and influences on transduction and its most basic conceptual positions in chapter one, and the more complex development of transduction in light of physical, chemical and biological scientific examples and theory in this chapter. These two chapters have also analysed Simondon's notions of energy and information as we understand them, providing a foundation for the rest of this thesis. It might have been noted that our focus in this chapter was often orientated towards unity, whether the central commanding of crystalline individuality, or discussion of the problem of unifying a living multiplicity. Thus far, whilst we have begun to discuss the temporal singularity of transduction, in these first two chapters we have emphasised transductive ontology in broad terms, focussing on the nature of transductive beings rather than transductive individuation. By and large, however, for

Simondon transduction refers to an individuation, and not just any transformation of energy. As such, it is the *singularity* or uniqueness of transduction to which we must turn in the following chapter.

Chapter Three - Creative mediation: preindividuality and compatibility

Up until this point we have focussed primarily on transductive beings rather than transductive individuations. We now turn our attention to the problem of singularity or individuality as it appears in *L'individuation*, attending in particular to the sense in which transductive beings are individuating mediations of the indeterminate and the determinate.

The first section of this chapter discusses Simondon's temporal criticism of principles of individuation, and in particular, the sense in which they fully constitute an individual before its existence, rendering the duration of individuation insignificant for the individuality of a being. In this way, individuality is given in potential and in advance, whilst actualisation adds nothing but existence. Simondon's transductive argument turns this on its head, contending that the true source of individuality is genesis itself, not what existed before or what exists as a result of a completed genesis. We then discuss the temporal dimension of individuation, or the sense in which the characteristics of an individual cannot be given in advance; instead, the duration of individuation is an unpredictable and unique unfolding. In order to articulate the stakes of Simondon's position we discuss Bergson's criticism of principles of time - mechanism and radical finalism - which, we argue, similarly effect a pre-determination as principles of individuation. If temporality is to be individual or singular, it cannot be given in advance by mechanical or radical finalist principles, which leave no room for temporal indeterminacy. Transductive individuation, then, is not constrained by strict principles of individuation or principles of time.

In the second section, we then explore and defend the claim that the preindividual is an indeterminate source in Simondon's ontology. In light of our initial reflection on principles, we argue that preindividuality is a marginal or partial indeterminacy relative to determinacy or limitation. In this regard, we contend that readings which express the preindividual as the source for everything, both the indeterminate and the determinate, underestimate the mediating nature of individuals in Simondon's text. Rather, we

propose that the preindividual ought to be read as a partial indeterminacy relative to the determinate, a charge which drives the duration of individuals, rendering complete individuation and absolutely determinate time impossible.

In the third section we argue that individuation, for Simondon, ought to be understood as a mediation of the indeterminate charge of the preindividual and the determinate, as expressed by scientific thinking. In this regard, we discuss Simondon's reflections on the conditions for information, emphasising the sense in which compatibility, as well as difference, is required for information. In contrast to Alberto Toscano's reading of Simondon's disparity as incompatibility or pure preindividual difference, then, we argue that instead disparity requires both compatibility and difference.

Our discussion of disparity opens up a broader reflection on the requirement for compatibility between individuations and determinate aspects of nature. In this regard, we discuss Simondon's example of the electromagnetic spectrum, which both makes transductive acts like photosynthesis or sight possible, but also limits what is possible, to the extent that the laws of electromagnetism, for example, cannot be overcome or exceeded. It is as compatible creative difference, between the indeterminacy of the preindividual and the determinate aspects of nature, then, that Simondon's transductive individuation takes place. We reflect, finally, on the sense in which individuals in Simondon's text, are further constrained by the specific limits laid out in the examples and scientific thinking in *L'individuation*.

1. The problem of the already constituted individual

In the very first pages of *L'individuation*, Simondon argues that previous attempts to grasp individuality - atomism and hylomorphism - have failed because they attempt to do so with a principle of individuation which serves, ultimately, to obscure individuation proper. Atomism assumes that individuals or atoms are given eternally as the substantial terminal foundation for accidental creation: "the principle of individuation, for atomism, is the very existence of the infinity of atoms: it is always already there at the moment when thought wants to realise its nature".[221] Atomism does not have a principle which explains genesis, then, but instead posits the existence

[221] Simondon, G. (2013), 24.

of individuals. There is no principle of individuation for atomism, which instead begins from the notion that atoms must already exist - this is a principle or starting-point for atomism. Relations and generations may abound in the atomistic image, but they are only accidents of substantial atoms. Substantial genesis and substantial relation are thus forever obscured.

Hylomorphism marks an improvement on atomism to the extent that it asks after the genesis or individuation of the individual. However, it obscures genesis proper in seeking a source or principle prior to individuation: "the principle of individuation is thus not grasped in the individuation itself as an operation, but in what this operation requires in order to exist, that is, a matter and a form."[222] The hylomorphic principle of individuation has nothing to say about genesis itself: the meeting of matter and form and the actual operation which produces an individual. Rather, the hylomorphic approach is perpetually too early, it is to "always place oneself before this taking of form",[223] thinking what is required in order to constitute an individual without thinking individuation itself. Even if we suppose that individuals are composites of matter and form, this does not explain the genesis of such an individual, the communication between matter and form that Simondon discusses in terms of brickmaking. Ultimately, hylomorphism thinks only the "extreme terms" of genesis, the constituents of an individual and the constituted or individuated individual, but not genesis itself.[224] Atomism arrives too late, then, as substantial individuation has already happened, whilst hylomorphism arrives too early, attempting to think individuation according to the constituents required for genesis without thinking the actual genesis.

Both atomism and hylomorphism also suffer from the assumption that individuality is given in a stable, constituted or individuated individual, rather than an individuat*ing* being. Their conceptions of individuation are thus structured around a static substantial foundation. Atomism simply posits this static in-divisible seat for genesis, whilst hylomorphism works backwards, attempting to think individuation in the shadow of the constituted individual. If some of Aristotle's expressions of hylomorphism have the benefit of attempting to think substantial genesis, genesis proper is obscured by a

[222] Ibid.
[223] Ibid.
[224] Ibid.

principle produced in the image of a constituted individual. Hylomorphism thus takes a different route from atomism, but is hampered by the same initial assumption:

> Both suppose that there is a principle of individuation anterior to the individuation itself, capable of explaining, producing and driving. From the constituted and given individual, one attempts to return to the conditions of its existence… *Such a perspective in research accords an ontological privilege to the constituted individual*.[225]

The problem with both atomism and hylomorphism is that they ignore individuation or the genesis of individuals. Both offer a principle of individuation in order to explain the genesis of the constituted or individuated individual, but they fail to explain individuation itself and individuat*ing* beings.

Examples of constituted individuals might be bricks, crystals or vacuum tubes. They are all individuated beings which do not require a relation to a milieu in order to exist. They may be becoming, but it is a degradation rather than an ontogenesis. If Simondon's argument permits them,[226] constituted individuals are those which are entropic, which do not require available energy in order to exist (they are not negentropic like transductive individuals). We have discussed much of Simondon's resolution to this problem already in the previous two chapters: both the sense in which he argues that relation to a milieu is necessary for individuals - that relation is substantial rather than accidental - and also the sense in which transductive individuals continue individuating - they never reach constituted status or "entelechy". Our primary interest in this chapter, then, is the sense in which these transductive beings are individuals, that is, singular or unique.

Indeed, the principle of individuation is not only a principle which brings-into-being, but also one which bestows individuality or uniqueness. A principle of individuation may be considered the final determination in a descending series from genus through species, that which determines an *infima species,* making the transition from species to

[225] Ibid., 23.

[226] It might be said that Simondon would not call these beings individuals as they are not individuating, or equally, as Barthélémy suggests, that technical objects are extensions of an already existing individuation (they are "individualisations" in Simondon's terminology). We merely mean to exemplify "constituted individual", however, which is what Simondon is attempting to move beyond. Barthélémy, (2005a).

individual. Alternatively, if the problem of universals is considered a Platonic problem resolved by Aristotle's nominalism,[227] then a principle of individuation will be considered simply that which drives coming-into-being. Indeed, if everything that comes-into-being is an individual, then a principle of individuation and principle of ontogenesis are equivalent. Either way, a principle of individuation both brings-into-being and bestows individuality.

The problem with principles of individuation, for Simondon, is that they negate any significance that the temporality of individuation may have. The principle contains individuality in advance and produces the individual in one fell swoop, whilst the duration of genesis does not affect the individual:

> In this notion of a principle, there is a certain character which prefigures constituted individuality, with the properties that it will have when it will be constituted…in order to account for the genesis of the individual with its definitive characteristics, it is necessary to suppose the existence of a first term, the principle, which bears within it that which will explain why the individual is individual and account for its haecceity.[228]

The singularity or haecceity of the individual is given by the principle, which prefigures the characteristics of the individual before it exists. Genesis itself is of no consequence for the nature of the individual and appears to be a mere formality in the production of an individual, which is given in advance by the principle.

Simondon attempts to turn this account on its head, arguing that the before and the after, the principle and the constituted individual should not be the focus when thinking individuality. Instead,

> The genuine principle of individuation is genesis itself in its operating [*en train de s'opérer*], that is, the system in the process of becoming, during which energy actualises itself. The genuine principle of individuation cannot be sought in what

[227] Regis, E. Jr. (1976), 166.
[228] Simondon, G. (2013), 23.

> exists before individuation is produced, nor in what remains after individuation is accomplished.[229]

The individuality of transductive beings, then, is not determined by something prior to individuation, nor given in an existence after individuation or genesis. It is the operation of transductive mediating, relational or communicative genesis that brings-into-being and maintains being. Individuality is coextensive with individuation, according to Simondon, and the principle for individuation thus becomes "genesis itself".

In describing genesis as the genuine principle of individuation, Simondon shifts the constitution of individuality from a metaphysical source pre-existing creation, to the whole period or duration of genesis itself. Individuality is not given in advance or all at once by a principle, but instead, individuality must be thought as genesis or individuation. In this way, the problem of individuation no longer entails the analysis of constituted beings in order to identify what makes them individuals (whether matter, form or their composite). On the contrary, the singularity of transductive individuals is coextensive with their temporality, and thus the problem of individuation becomes one of grasping the duration of transductive beings.

Simondon does not use the term "duration", nor in fact does he offer extended reflection on the temporality of transduction. Nonetheless, it is worth lingering on Bergson's defence of duration, as it describes many of the demands of Simondon's position. Bergson argues that time and categorisation obscure the continuous and unique unfolding of duration with a series of identical moments or forms. Moments of clock-time (seconds, minutes, hours and so on) or categories of thought reduce the singular differentiation of duration to identity, and so replace the uniqueness of duration with something pre-constituted. The identical is cut-out of the flow of duration, leaving the unique or singular obscure. Such is the force of clock-time and our everyday categories of thought that we forget or ignore that our true temporal experience is continuous and durational.[230]

Something very similar is at the heart of Simondon's critique of principles of individuation. The hylomorphic individual is prefigured by a principle which contains in

[229] Simondon, G. (2013), 48.
[230] See, for example, Bergson, H. (1968) 76-82.

advance "the properties that it will have when it will be constituted", whilst that principle is thought in light of a constituted individual, according to "a genesis in reverse".[231] Ironically, even the singularity of the individual is given in advance by the principle, "which bears within it that which will explain why the individual is individual and account for its haecceity".[232] The duration of individuation is obscured by the prefiguration of what will be created. What is important, for both Bergson and Simondon, then, is the actuality or reality of temporality, not what can be given in advance - principles of individuation or time - or what is given after genesis or abstracted from it - the constituted individual or categories which cut out the identical from the differentiating.

Bergson's and Simondon's positions differ, however, in terms of the scale at which duration might be grasped as a whole. Whilst duration in *Creative Evolution* is thought according to an impetus which incorporates and expresses the whole of life - the *élan vital* - *L'individuation* presents singular temporality at the level of the individual. Equally, whilst for Bergson life is continuous to the extent that its parts are interconnected expressions of the *élan vital,* for Simondon individuals are discontinuous, each a quantum of singularity. Although, for Simondon, individuations relate to a preindividual charge or energy, this does not express their continuity or unity with one another. As we discussed previously, whilst Bergson proposes that individuality is always incomplete to the extent that individuals are produced by and depend upon one another, Simondon attempts to divide individuals from their milieu (including other beings of which it is made up) even whilst they depend on it. With regards to continuity, the living individual in *Creative Evolution* is the whole duration of life, whilst for Simondon it is at the level of a potentially infinite, discontinuous multiplicity of beings.[233] This has significant implications for the character and possibility of temporal singularity in Simondon's text, which we will draw out throughout this chapter. But first we must briefly discuss Bergson's critique of

[231] Simondon, G. (2013), 23.
[232] Ibid.
[233] On a number of occasions Simondon contrasts Spinoza's and Leibniz's conceptions of the individual, the infinite whole for the former and the infinite plural for the latter. To a certain extent (their substantialism not withstanding), Bergson's and Simondon's positions might be considered in the same way: the former grasps duration at the level of the whole of life, whilst the latter at that of individuality.

principles of time - mechanism and radical finalism - in order to better grasp the stakes of Simondon's position.

Principles of time: mechanism and radical finalism

We have seen that for Simondon, transductive individuals are individuations; their individuality cannot be given in advance by a principle, nor are they given all at once as constituted individuals. Instead, transductive individuals are an individuation or an ontogenetic duration. This is the sense in which we can understand the following claim:

> we will try to grasp ontogenesis in the whole unfolding of its reality, and to know the individual across individuation rather than individuation from the individual.[234]

The individual is not given by a principle or encapsulated by an individuated, constituted or static being. The individuality of a being instead consists in its individuation, or "the whole unfolding of its reality".

If individuals are temporally unique, as Simondon contends, the duration of individuation cannot be determined in advance. This leads him to argue that the individual is always partly indeterminate, never fully given but always self-differentiating. This conception is unlike a negative conception of individuality, whereby an individual would be determined as *not* every other being, thus rendering it unique. Such a conception requires a fully constituted or determined individual, whilst for Simondon the individual is always open to preindividual indeterminacy.

But the problem is not only with principles of individuation, which would prefigure and constitute singularity to produce a fully determinate and static individual. Principles of time are similarly problematic to the extent that they reduce the future to a function of the past, pre-determining any temporal unfolding. In this regard, Bergson's criticism of mechanism and radical finalism delineates the stakes of a philosophy of durational uniqueness and indeterminacy such as Simondon's.

[234] Simondon, G. (2013), 24.

"Radical mechanism", for Bergson, describes a conception of time governed by a strict causal principle.[235] In this way, relations between material points are determined by a mechanical or causal principle which leaves no margin for indeterminacy, creativity or chance. Every action has an equal and opposite reaction, and thus each change is wholly determined by a prior cause. Such a strict mechanical principle would also determine change such that it is theoretically fully predictable. If the position and momentum of all material points in the universe at one moment could be known, then its whole past and future could be predicted with absolute precision. The evolution of the universe would be utterly determined by initial conditions unfolding according to the absolute governance of a mechanical principle, there would be no margin for indeterminacy, creation or chance. As Bergson puts it, "The essence of mechanical explanation, in fact, is to regard the future and the past as calculable functions of the present, and thus to claim that *all is given*."[236] If principles of individuation determine the future individual, mechanical principles determine the future *tout court*.

What is significant about the mechanical picture is not that it is possible to actually predict the whole past and future of the universe, rather that this is theoretically possible on the basis of knowledge of the principle which governs causal change. Pierre-Simon Laplace makes this claim in his famous thought experiment, in which he proposes that a non-human intellect could predict the whole future and retrodict the whole past based on a snapshot of the position and momentum of material particles. This absolute knowledge requires an intellect capable of cognising the totality of bodies in the universe, and knowledge of the principle which governs their motions and interactions. Humans lack the former but not the latter, according to Laplace. Thus, he writes that

> An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of

[235] Bergson, H. (1941 [1911]), 37-9 [43-45].
[236] Bergson, H. (1941 [1911]), 38 [43].

> the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes.[237]

If there were an intellect able to grasp the forces, motion and position of all the bodies in the universe at one moment, it could also gain knowledge of the past and the future with certainty, based on the causal chains (forward and backwards) made possible by the mechanical principle. Laplace's demon only requires a snapshot in order to know the past and the future because change is entirely determined by the principle. Each change leads necessarily to the next without indeterminacy, and thus changes could be mapped according to the necessity of the principle and the state of bodies, forwards or backwards forever.

Under the governance of a mechanistic principle such as this, everything is given at the beginning and there is nothing creative or aleatory for all eternity. Things may be unpredictable or appear uncaused, but this is really a function of ignorance or an inability to grasp the totality of determinate causation. Human intellects cannot cognise the position and momentum of all of the bodies of the universe, and thus we cannot predict absolutely, according to Laplace. If we can know and prove this principle at some scale, and so too the fact that it describes any and every change, then we can know that all changes in the universe are determinate, and hence, given in-advance. Even if we cannot know the universal content of change, we are able to know its universal form, and above all, that all change is determinate.

The problem with mechanism, according to Bergson, is that it renders actual time or genesis insignificant as it is reduced to the realisation of something absolutely predetermined. Indeterminacy, creation and chance are impossible, and thus the actuality of change gives nothing that was not given from the beginning. As with principles of individuation and the constituted individual, genesis proper appears like a mere formality and temporal change is the appearance of something wholly pre-constituted. Everything is given at the beginning of time and no room is left for the indeterminate, creative or aleatory.

[237] Laplace, P. S. (1951), 4.

Bergson is not alone, of course, in worrying about this problem. Kant sets up such a mechanical principle in his first *Critique* and tries to get around it with the possibility of noumenal freedom in the second *Critique*.[238] Today "radical mechanism" is a position of largely historical interest, after decisive scientific interventions, primarily in the first half of the twentieth century. The fields of quantum mechanics, non-equilibrium thermodynamics and evolutionary biology have seemingly proven that temporality is, at some scale, unpredictable. Philosophy has been somewhat slower to acknowledge this transition, but there have been a number of recent texts which attempt to work through the implications of these scientific developments for notions of temporal unpredictability, creativity and difference.[239]

Bergson and Simondon, in this regard, were early advocates of such a notion of creation or temporal indeterminacy. Both maintain that indeterminacy in temporality is not a function of intellectual ignorance - an incapacity to grasp the position and momentum of all bodies *and* the principle determining their change - but an aspect of life or being itself. For Bergson, indeterminacy is a fundamental aspect of life impelled by the creative energy of the *élan vital*, whilst for Simondon, as we will see, every individuation is generated, in part, by indeterminate preindividual energy. Both maintain that change is not given absolutely in advance and crucially that the actuality duration, genesis or individuation are constituent of the nature and characteristic of beings; and it would seem that history, in this regard at least, has been kind to them.

Before we discuss the detail of Simondon's proposition for a source of indeterminacy, however, we must first briefly discuss finalism, the other option that Bergson proposes for thinking temporality. Finalism comes in "radical" and non-radical variants, according to Bergson; the former he criticises and the latter he affirms as a part of the general position in *Creative Evolution*. Much like radical mechanism, radical finalism reduces becoming to the actualisation of a program and change to the pre-constituted. Radical finalism fully determines becoming according to a form or entelechy which is given in advance. What a being will become is thus fully pre-constituted, and its generation merely involves the achievement of this finality. A principle of individuation

[238] Kant, I. (1998), 304-316; (2015).
[239] See, for example, De Landa, M., (2013); Deleuze, G. (1968 [1994]); Prigogine, I. and Stengers, I. (1984).

which contained the individual in all of its characteristics in advance or potentially is an example of this.

Radical finalism, then, is only an "inverted mechanism",[240] for Bergson. Whilst for mechanism an initial impulsion comes from "behind", transformed without loss through every change in nature, with radical finalism, a form or an end draws changes towards them from in front.[241] Crucially, neither mechanism nor radical finalism leave room for indeterminacy, and duration or generation does not affect or alter the pre-constituted plan. In both cases, genesis makes no difference, as everything is given in advance: "if there is nothing unforeseen, no invention or creation in the universe, time is useless. As in the mechanistic hypothesis, [for finalism] again it is supposed that *all is given*."[242]

It is only *radical* finalism which is so similar to mechanism, however. Finalism is more flexible than mechanism, for Bergson, and crucially it may include variants which are open to indeterminacy and creativity. Mechanism is all or nothing - with the "slightest trace of spontaneity" it must be given up all together - whilst finalisms come in rigidly deterministic variants, but also those which admit a margin for creativity and chance.[243]

Deterministic "external" finalism, such as that which would lead to harmony amongst beings is impossible, according to Bergson, on account of the fact that beings exist in discordance with one another.[244] Equally, he contends that an "internal" finalism is impossible, whereby the generation of beings is the fulfilment of a preordained plan and the parts of each being are subordinated to a whole. The reason is that parts have proper autonomy; cells and individual beings (the latter parts of unities like a germ plasm or a lineage) are parts of greater unities, but they are not fully determined by them; there is always a margin of indeterminacy.[245]

There is, however, a real finality in what Bergson takes to be the drive or desire of the *élan vital* for indeterminacy: "at the root of life there is an effort to engraft on to the necessity of physical forces the largest possible amount of *indetermination*".[246] Equally,

[240] Bergson, H. (1941 [1911]), 39 [45].
[241] Ibid.
[242] Bergson, H. (1941; [1911]) 39 [45].
[243] Ibid., 40 [46].
[244] Ibid.
[245] Ibid., 42 [48].
[246] Ibid., 116 [127].

he accepts that tendencies such as those of the plant and the animal and their respective species are finalities in the weaker, less radical sense. These are not determined absolutely in advance, but they are tendencies nonetheless, maintained by the differential repetitions of living reproduction. Whilst the *élan vital* may be an effort for maximum indeterminacy, it is always limited by physico-chemical forces or "matter" in Bergson's terminology. Matter is necessary and given in advance, but also required for life or the survival of living beings. It thus constrains the indeterminate energy of the *élan vital*, forcing life into broad tendencies and species of being.[247]

Although Bergson suggests at one point that the *élan vital* overcame the limits of matter long ago,[248] more profoundly his general description of the duration of life is a mediation between the indeterminate drive of the *élan vital* and material or physico-chemical necessity. All is not given in advance as it is in light of a mechanistic principle, but something is given in advance, nonetheless. Matter or the laws of physics and chemistry are eternally necessary limits on creativity. This means that the *élan vital*, which desires the greatest possible indeterminacy, must mediate the necessity of matter, working with it or in its margins in order to produce the indeterminate duration of its creative evolution.

The reason that this is significant for our discussion of Simondon, as we discuss in detail below, is that his conception of singularity involves a mediation of the indeterminate energy of the preindividual and the determinacy of scientific theories and examples. Bergson's discussion of principles of time allows us to grasp the stakes of Simondon's philosophy of individuation as a singular temporality or duration, whilst his distinction between the indeterminacy of life and the determinacy of matter or physico-chemical necessity gives us the broad structure of transductive individuation in Simondon's text. As we will see, however, Simondon is more cognisant or accepting of the demand for a mediation between an indeterminate charge and natural necessity, which, in turn, limits the creative capacity of individuation.

[247] This, of course, is to say nothing of a third countervailing desire for simplicity or ease of life - "the living being leans naturally toward what is most convenient to it" - which Bergson rather neglects in comparison to the duality of life and matter. Bergson, H. (1941), 114 [126].
[248] Bergson, H. (1941 [1911]), 99 [110].

We have thus begun to demonstrate the relation between indeterminacy and determinacy at the heart of Simondon's transductive ontology, which, we contend, has been hitherto underestimated by Simondon's readers. We argue instead that preindividuality is an indeterminate energy which drives individuation, but that it must be thought as relative to and constrained by the natural determinacy or necessity expressed by the scientific theories and examples which make Simondon's ontology possible.

2. Source of indeterminacy: preindividual nature

Preindividuality is crucial to grasping the whole project of *L'individuation*, but it is a complex aspect of that text which suffers from brief and obscure exposition therein. The preindividual is a source of indeterminacy which begins and sustains individuating beings, but as a driver of individuation which produces temporal indeterminacy, we contend that it must be grasped *relative* to the determinate. In this way, preindividuality avoids the determinist or radical finalist sense in which everything is given in advance. However, it is must also be recognise that *something* is given in advance. The preindividual should thus be considered a source of marginal or partial indeterminacy relative to the determinate or necessary.

In making this interpretation, we contend that there is a problem or at least an obscurity in Simondon's presentation of preindividuality, to the extent that he suggests, on occasion, that the preindividual is an absolute origin, the source of anything and everything.[249] The problem is that if everything is given by the preindividual, then although this may appear to say a great deal - articulating a genetic source for all beings - it really tells us nothing, as it merely gives the reason for everything existent in some metaphysical non-existent. But whilst Simondon's presentation of the preindividual may at times, suggest such a reading, it is above all his readers who crystallise this metaphysical step. Furthermore, in so doing his readers underestimate the more significant sense in which Simondon articulates the preindividual as a marginal

[249] For example, when the preindividual is described as "the first phase of being" or the "*being in which no phase exists*" phase of being. Simondon, G. (2013), 297; 25 [italics original].

indeterminacy which drives individuation, which in turn, must mediate natural determinacy expressed by scientific theories and examples.

The other common problem in texts on Simondon's work is to read preindividuality as part of the meagre and rather vague proposition that being is neither stable nor unstable, but metastable. With regard to these two problems, readers are caught between saying too much and too little when discussing the preindividual. Muriel Combes and Simon Mills, for example, say too little when they propose, respectively, that "Thinking pre-individual being as a system that is neither stable nor unstable demands recourse to the notion of metastability",[250] or that

> this state cannot be wholly stable; for it to be so would mean that it were fully substantial (in the Aristotelian sense). Instead it contains within itself the potential for transformation.[251]

Simondon does indeed make an analogy between the metastability of a crystalline liquid and the preindividual, but Combes and Mills do not draw the right conclusions from this. In Simondon's text, preindividuality no doubt describes potential for change, but its "metastability" is not the decisive philosophical contribution that they make it out to be. Indeed, after Parmenides, and certainly from Aristotle onwards, few have maintained that beings are "stable" or incapable of transformation. Thus, if the contribution of metastability is that it describes partial stability, "neither stable nor unstable", this goes no further than Aristotle's conception of potentiality and actuality, or his discussion of hylomorphic generation.

In this sense, Mills does not recognise that Aristotle's innovation was precisely to think stability relative to instability. What he describes as "fully substantial" for Aristotle, crucially has an accidental counterpart which has the capacity for change. When it comes to Aristotle's philosophy, the crux of the matter is not that it only thinks stability, but that stability precedes and limits genesis in advance. There are substantial and accidental geneses in Aristotle's work, but they are already contained by specific forms which cannot evolve, or equally, the flux of the sublunary world is fundamentally

[250] Combes, M. (2012), 3.
[251] Mills, S. (2016), 36.

constrained by the necessary stasis of the superlunary.[252] As we saw in Bergson's discussion of mechanism, the important point is the nature of instability and change. It is not enough to present Simondon's contribution to philosophy as the articulation of being which is becoming; as we have seen, transformation and flux are fundamental to both Aristotle's conception and to a mechanistic world view, only they are rendered determinate by principles which govern change in advance.

Combes and Mills claim too much for the preindividual, then, when they propose, respectively, that it is "The source of all individuals",[253] or that

> energy and matter are two complementary dimensions that arise from the individuation of the pre-individual; they are 'manifestations' of the pre-individual.[254]

We can see why Combes might advance something like this, since Simondon identifies preindividuality with Anaximander's *apeiron* (the indeterminate or unlimited) often considered the *arche* - source or origin - of all beings. Equally, regarding Mills' contention, Simondon does indeed suggest that preindividuality might be considered a condition for dualisms such as individual-milieu and wave-particle.[255]

The problem, as we said above, is that if preindividuality has such absolute generative power that it creates "all individuals" or gives rise to aspects of Simondon's ontology as fundamental as energy and matter, it tells us nothing about beings as they actually are. Indeed, whilst preindividuality would be a source which could explain and produce everything - all individuals, matter and energy, sub-atomic particles - it no longer has any relation to the beings it would create, it is totally untethered from the actual. In this

[252] Miguel de Beistegui makes this point incisively in his discussion of Aristotle's physics. De Beistegui, M. (2004), 29-77.
[253] Combes, M. (2012), 3.
[254] Mills, S. (2016), 37.
[255] Above all, it would seem Mills' position ultimately derives from a misunderstanding of energy, whereby he argues that we should not "equate the pre-individual with energy. That is, the preindividual and energy are not equivalent, a fact that should be obvious when one considers that energy = mass x velocity^2." (Mills, S. (2016), 37). Energy is of course not equivalent to the formula for kinetic energy which Mills supplies above. More significantly, however, Mills both reifies energy and reduces it to a formula. Formulae are means with which to grasp manifestations of energy, but they are not equivalent with energy in-itself.

sense, it would be as if Bergson had proposed a source for life *and* matter, both *élan vital* and physico-chemical forces, the origin of everything.[256]

As we mentioned above, Simondon proposes that preindividuality could be considered like Anaximander's *apeiron*. Thus, he writes that

> we could call nature this preindividual reality that the individual carries with it, in seeking to retrieve the meaning that the pre-Socratic philosophers gave to the word nature: the Ionian physiologists found the origin of all the species of being, anterior to individuation… According to the hypothesis presented here, the ἄπειρον [*apeiron*] would remain in the individual, just as the crystal retains its mother-water, and this charge of ἄπειρον would permit going towards a second individuation.[257]

In the passage above it is clear that preindividual reality, or the *apeiron* is relative to or carried with the individual as a source. What is crucial, then, is whether we read the preindividual simply as "the origin of all species of being, anterior to individuation" or as a marginal indeterminacy. The latter sense is of course closer to that of Combes and Mills, where *apeiron* is the origin of everything. It is worth noting, even in this short passage, that Simondon renders this a "charge of ἄπειρον", like the available energy that mother water (supersaturated liquid) provides a crystallising individual. In this sense, we contend, this charge of *apeiron* is not simply the source of everything, but a partial or marginal indeterminate potential, analogue to the available energy provided by supersaturated liquid relative to a crystallising being.

Ultimately, the origin of the reading of the preindividual as all-giving source might be traced back to the common interpretation of Anaximander's *apeiron*, which suffers from a similar problem to that which we identified above regarding the preindividual. Simply put, if the *apeiron* is given as the creator of everything, it tells us little or nothing about beings as they actually are, but claims them as its products, nonetheless. One might thus identify Simondon's consideration of the preindividual straightforwardly with *apeiron* in the Anaximander fragment, that is, as an "unlimited nature, from which all the

[256] In this regard, the preindividual is presented as a God, though lacking any attempt at an ontological proof.
[257] Ibid., 297.

heavens and the worlds in them come about".[258] In this respect, Mills is at pains to affirm, against anything "scientific", the metaphysical sense of the preindividual in light of Anaximander's *apeiron*.[259]

Nietzsche recognises the problem that we are referring to in one of his criticisms of Anaximander's *arche*, arguing that positing the "unlimited" or "indefinite" as the source for everything limited or definite is to untether thinking from what actually exists. In this way, Nietzsche contends that Anaximander's *apeiron* is indeed a metaphysical supposition for an origin of all beings, which he argues, involves a flight from the actual to a "mystic possibility", "into the womb of the metaphysical 'indefinite' to escape the definite qualities".[260] Thus, Anaximander's thought leaves the world as it actually is in order to posit its fundamental condition. The latter, of course, is of little help if the problem is to explain beings as they actually are. This reading of Anaximander's *apeiron* is thus like that which presents Simondon's preindividual as the source for everything - all individuals, matter and energy, and subatomic particles.

Whilst Simondon undoubtedly likens the preindividual is like Anaximander's *apeiron* (as we saw in the passage above), it is as a marginal indeterminate energy relative to the determinate: a "charge of ἄπειρον",[261] that is, a charge of the indeterminate. In this way, whilst Mills recognises that the preindividual is influenced by scientific thinking, he fails to recognise that it is precisely a source of indeterminacy that relates to the determinacy expressed by scientific theories and examples.

It is worth noting, briefly, that preindividuality takes on a range of different meanings in *L'individuation,* and Simondon's exposition is often less precise that one might wish. He describes protozoa and some corals, for example, as "preindividual" forms of life to the extent that they are not individual in the sense that beings are which have informational autonomy or the capacity to live apart from an initial vital group.[262] But this logical, or

[258] Barnes, J. (1982) 21.
[259] Thus, Mills claims that "Although Simondon's inspiration for the notion of the pre-individual is predominantly scientific, it is described in distinctly metaphysical terms, at times likened to the apeiron described by Anaximander. Therefore although Simondon's metaphysics draws heavily on physical and biological science, the ground remains distinctly philosophical and metaphysical in character and not susceptible to scientific reduction. Hence the pre-individual is not a scientific concept but a philosophical one." Mills, S. (2016), 37.
[260] Nietzsche, F. (1962), 50; 58.
[261] Ibid., 297.
[262] Simondon, G. (2013), 168; 170-3.

epistemological sense is not the same as the meaning expressed in the rest of *L'individuation*.

Primarily, preindividuality is expressed as a potential or energetic dynamism which exceeds the constituted individual, in the sense that "individuation does not exhaust all at once the potentials of preindividual reality".[263] These preindividual "potentials" should not be considered in the Aristotelian sense of a *dunamis*, a potential limited in advance by the actuality for which it is the capacity. Preindividual potentials, on the contrary, are not determined in advance, but are instead an indeterminate energy or charge. In this way, Simondon writes (as we saw above) that preindividuality can be considered a charge relative to the individual, like the "ἄπειρον [which] would remain in the individual, like the crystal retains its mother-water".[264] In this sense, *apeiron* is not the "infinite" or "boundless" creator of everything, but an "indeterminate" charge or potential relative to the determinate or limited.

Preindividuality is not an *apeiron* in the sense of an *arche* which is the absolute well-spring or "womb of all things",[265] but a partial or marginal indeterminate energy relative to and constrained by determinacy. When Simondon discusses the pre-Socratics and ancient Greek thinkers in *Histoire de la notion d'individu*, he reads from the Ionians onwards, tracing the increasing domestication or control of pre-Socratic *archai*. Aristotle's philosophy does not so much exclude *physis* - nature considered as a growing and changing reality - but rather limits it in advance. As Simondon reads it, Aristotle's nominalist actualism reduces the generation of individuals to the constituted individual and the generation of living beings to prior species forms.[266] Change is thus always limited in advance, for Aristotle, as *energeia* is prior to *dunamis* in every sense; potential does not break the bounds of the actual or introduce some chance or creativity, it only realises something already given. In this sense, paraphrasing Bergson, *everything is given in advance.*

The pre-Socratic *archai* that Simondon is most interested in when it comes to the pre-Socratics - *apeiron* and *physis* - are thus not like principles of individuation or of

[263] Simondon, G. (2013), 25.
[264] Ibid., 297.
[265] Nietzsche, F. (1962), 38.
[266] Simondon, G. (2013), 380-387.

mechanism and radical finalism. Indeed, if we are correct that for Simondon the preindividual or charge of *apeiron* is an indeterminate energy, it is the contrary of a principle which governs, controls or indeed, determines. A mechanistic principle, as we have discussed, controls the temporal relation between bodies such that there is no margin for indeterminacy, but the preindividual works in precisely the opposite way, introducing indeterminacy into time. Equally, whilst a principle of individuation may be considered the source of an absolute negative determination of an individual,[267] preindividuality is an indeterminate excess, potentials to which individuals relate which persistently drive their further individuation. If a principle of individuation secures a being as fully individuated or constituted by dint of negative determination (as not every other being), the preindividual is an excess which would make this impossible. For Simondon, there is no final and total determination or fulfilment (*entelechy*) of a transductive individual, but continuous individuation and then termination or death. The meaning of the preindividual which we have been articulating, then, is the contrary of the notion of a principle which governs change or negatively determines a being as an individual.

We must also note, however, that the preindividual is not the same as Anaximander's *apeiron*, rather it is a "charge of *apeiron*",[268] relative to an individuating being, which is in part determined in advance. The preindividual is an indeterminate (*apeiron*) source (*arche*) in the sense that it is an energetic indeterminacy. It is a charge which drives individuation such that there is never a constituted individual and expresses the impossibility of mechanistic pre-constitution of time. But crucially, as we will discuss in the following section, the preindividual is a marginal, rather than an absolute creative source.

Returning to the problem of a durational or singular temporality which we discussed above, we can now see that the preindividual is a source for individuation which drives the becoming of a being such that it is never a constituted or fully determined individual. Equally, in contrast to the time of mechanism and radical finalism, an individuation is not given in advance, but a function of a durational or ontologically

[267] That is, the final determination in a descending series from genus, through species, to individual; a principle which would produce singularity *qua* negative determination, or an individual *qua* not every other being.
[268] Ibid., 297.

indeterminate time. Whilst indeterminacy was a function of ignorance or intellectual incapacity in Laplace's description, in Simondon's work it is a fundamental aspect of being, which is always partially indeterminate.

We have said consistently that the preindividual is a marginal indeterminacy, an energy relative to the individual and to the determinate. Individuation, in Simondon's philosophy, is not governed by a mechanical principle, such that every change is determined in advance, nor is it a radical finalism, like Aristotle's, whereby any change leads towards a form given in advance. But neither is everything indeterminate, in Simondon's work. Maintaining this would lead to the reading of the preindividual we argued was erroneous. At one of its furthest limits, this is similar to the position which maintains that any scientific law could be overturned and that anything could happen, because all expressions of determinacy lack absolute proof, or what is held to be causal is merely correlational.[269] On the contrary, as we have been arguing, Simondon's philosophy is in part constituted by scientific thinking, and it is therefore full of determinations or limitations given in advance of any individuation.

As Bergson argues, "the force which is evolving throughout the organized world is a limited force",[270] that is, the indeterminate energy of the *élan vital* is everywhere constrained by the determinate and or pre-givenness of matter or the species forms of living beings. But the limitation placed on the preindividual is not simply matter, as in Bergson's text, but rather a natural necessity which includes both matter and life. Indeed, for Simondon both matter - or better, sub-atomic particles - and life have a preindividual charge, but equally, both matter and life are partially determined in advance.[271] Individuation for Simondon (much like life for Bergson), is necessarily limited. In order to exist, beings must mediate the determinate. Thus, whilst preindividual nature may be thought as purely indeterminate or creative, it is never actually thus: it is nothing without limitation.

[269] Meillasoux, Q. (2008).
[270] Bergson, H. (1941[1911]), 127 [140].
[271] Whilst this division between the indeterminate and the determinate in Simondon's philosophy is resemblant of that between atoms and clinamen, potentially bringing Simondon's philosophy very close to that of one of his opponents in L'individuation, the difference is that the determinate, for Simondon, is not an infinite multiplicity of substantial beings, given in advance for eternity.

It is the relation between indeterminate energy and determinate limits, then, that is crucial for transductive singularity. Thus far, we have discussed the indeterminate charge of the preindividual in Simondon's work, and we now turn to that which limits it, to the determinacy which individuations and technical inventions must mediate in order to exist and individuate.

3. Partially given, necessary limitation

Transduction is a philosophy of mediation, as we have demonstrated in a number of senses thus far in this thesis. In this section we argue that transduction is a mediation between the indeterminate energy of the preindividual and natural determinacy. This will further evidence our contention that preindividuality does not simply create anything and everything, but is instead a marginal or partial indeterminacy. We will also introduce another contention, namely, that Simondon's philosophy is primarily centred around actuality or actualisation, rather than virtuality or preindividuality. In this way, we argue that in Simondon's conception of the conditions of possibility for information or disparity, that compatibility is of equal importance as difference. Whilst disparity is read by some as a discussion of preindividuality, understood as pure difference or incompatibility, we argue on the contrary that it is in fact a discussion of the conditions for the actuality of individuation, which precisely include compatibility. Rather than thinking pure difference, Simondon emphasises the conditions for the possibility of an actual difference, that is, difference compatible with natural determinacy.

We exemplify this discussion of the conditions for information by means of a discussion of the electromagnetic spectrum, which describes a field or range of possibility which can be mediated for sustaining operations of command or control. Electromagnetic radiation describes the nature of the fundamental source of energy on earth, whilst its laws, expressed by James Clerk Maxwell's equations and later as the electromagnetic spectrum, limit the capacity for creation. In this way, the determinacy of electromagnetic radiation limits the indeterminacy of individuation, constraining what is possible in terms of the receipt of energy from solar radiation. Equally, however, electromagnetic radiation makes the being of living beings possible and leaves a margin for indeterminacy. The laws of electromagnetic radiation, then, express the sense in which individuation is a creative mediation between the indeterminacy of the

preindividuality and the determinacy of nature, and helps to emphasise the sense in which determinacy both constrains and makes individuation possible.

Finally, we briefly discuss the sense in which - in Simondon's text, at least - transductive individuation is limited by the specificity of examples. In this sense, whilst Simondon attempts to free his text from thinking individuation according to generic and specific categories of beings, he reintroduces this form of thinking through his use of examples.

General limitation: signal, form, information

In the previous chapter we discussed the sense in which information entails command - a generation which transforms energy in a particular way, or *for* individuation - and with regards to living beings, control - regulation of the activity of a being in order to maintain itself within a changing milieu. This already assumes compatibility between the active and receptive capacities of an individuating being and its milieu. Here we will discuss Simondon's reflection on the conditions for the possibility of information, or the compatibility required between the "form" of an individual and "signals" which it receives. Careful examination of this notion of compatibility will both demonstrate Simondon's conception of the determinate limits placed on individuation, and more broadly it will begin to articulate the sense in which mapping or predicting these compatibilities between individual forms and environmental signals is in part the work of scientific thinking.

In the section entitled "De l'information à la signification"[272] Simondon proposes that it is difficult to derive a univocal notion of information from probabilistic conceptions, like that of Norbert Wiener or Claude Shannon and Warren Weaver, because information is presented as at once unpredictable and predictable. Information is unpredictable to the extent that it is negentropic, or improbable: "information is, as Norbert Wiener explains, what is opposed to the degradation of energy, to the augmentation of entropy of a system".[273] Equally, however, information is presented as predictable, according to Simondon, since it must be transmitted and received; that is, whatever receives an information signal must in some sense predict the nature of that information signal in order to have the capacity to receive it. In order that an information signal can have a

[272] From the section on living beings in *L'individuation*. Simondon, G. (2013), pp. 219-223.
[273] Simondon, G. (2013), 219.

"meaning" or be "efficacious" it must be predictable to the extent that it is such that whatever receives it is *able* to do so: "In addition to the quantity of information signals transmissible by a given system, it is necessary to consider their aptitude to be received by a receiving device".[274] The requirement for an aptitude or ability to receive an information signal limits or constrains the novelty or unpredictability of information. In this sense, information will be predictable to the extent that it must be compatible with the aptitude of the receiver in order to be received at all.

Simondon makes two significant and interconnected points in this section. First, he argues that the notion of information should require that a signal has meaning or is effective upon receipt. This is in contrast to the probabilistic notion of information, which gives messages or signals an informational value based on the likelihood of their content, regardless of meaning or effectiveness. Second, he contends that in order for signals to have meaning or effectiveness, they must be received by something with the aptitude to receive signals of this kind. In short, compatibility between signal and receiver is a condition for information.

Before continuing with Simondon's argument, it is worth briefly reflecting on Wiener's and Shannon's and Weaver's conceptions of information. The lack of detailed engagement with Wiener or other proponents of a probabilistic theory of information in *L'individuation* leads to a lack of critical precision on Simondon's part, particularly when it comes to the predictability of a message. In this way, Simondon accords Wiener the position that a signal of information is "not predictable", to which he contrasts his own contention that, in order to be received, an information signal must be partially predictably; thus, it cannot be "entirely new".[275]

Neither Wiener's nor Shannon's conceptions, however, present information as unpredictable or entirely new.[276] Rather, they argue that the content of a message is entirely predictable but variously improbable. The content of a message can thus be given an informational value based on its likelihood relative to the totality from which it is drawn. Simondon surely understands this, since he explains that information involves

[274] Ibid., 221.
[275] Simondon, G. (2013), 222.
[276] Both of whom arrived at almost identical results independently and nearly simultaneously. Shannon, C. E. and Weaver, W. (1964); Wiener, N. (1989).

a decision between states, only he does not take the thought through to its conclusion. Indeed, according to information theory, a message is made up of a series of parts selected from a totality. The probability of a particular message can then be calculated according to the probabilities of each part appearing relative to the others in that particular message. The information of a message, then, is calculated as the overall improbability of the whole message. Every possible combination (of letters in a message, for example) is given a probability. This means that every possible combination that could appear within a message is predicted and given an informational value in advance. In this sense, information is not entirely new.

An example may help to clarify this problem: if we take the total set of letters in the English language alphabet and calculate the probability of each letter appearing next to each of the others, we are able to ascertain the informational value of every possible combination of letters. The informational value of a whole message, then, can be calculated as the sum of the probability of each of these combinations. For example, it is rare that the letter "q" is succeeded by a letter other than "u" in English. The informational value of a letter "u" after a "q" in a message written in English will thus be lower than a "q" with a different succeeding letter. Similarly, the probability of a vowel succeeding "an" is greater than that of a consonant, and thus the informational value of the former is lower than the latter. Indeed, probability is a function of a total set of possibilities which are necessarily predetermined (in our example the total set of possibilities is the letters of the English language in relation to one another) and their likelihood as a function of actual instances. In order to calculate the probability of a message, then, every possible letter, every possible combination of letters and the likelihood of each combination must be known in advance.

If one decision can be said to be more probable than another - "u" rather than "i" succeeding "q" in the English language, for example - it is assigned a greater informational or negentropic value. Entropy or uncertainty (for Wiener and for Shannon respectively) can thus be defined correspondingly as the most probable message. An information signal or a message, then, involves a selection or decision (or a series thereof) from a totality, which is then given a value - "information" - according to its probability. Hence, Wiener's definition of information (or negentropy) is as follows:

> it is possible to interpret the information carried by a message as essentially the negative of its entropy, and the negative logarithm of its probability. That is, the more probable the message, the less information it gives.[277]

As the information or negentropy of a message is conceived probabilistically in these conceptions, every combination has been given in advance as a possibility (with an associated probability or likelihood), only it has not been actualised. The actuality is the message, of course, and its information is judged relative to its probability. Thus, the entirely new is inconceivable for information theory.

If Simondon does not properly grasp the sense in which information is given in advance in probabilistic theories of information, he nonetheless makes a significant point regarding the absence of meaning from these definitions of information. In this way, Simondon maintains that in order for an *information signal* to become *information*, it must have an effect on or a meaning for the receiver. This is in direct contrast to probabilistic theories of information, and most clearly Shannon's austere Mathematical Theory of Communication, which deals only with the engineering problems surrounding message sending or the possibility of communication. Indeed, Shannon's conception of information "characterizes the whole statistical nature of the information source, and is not concerned with the individual messages (and not at all directly concerned with the meaning of the individual messages)".[278] Shannon's theory deals only with probability as a function of the whole set of possible messages, not with the actual effects (or lack thereof) of a message. Thus, there is more information if a message is selected unbiased from fifty messages than from twenty-five, whether they are intelligible or not.[279]

Even if Wiener's conception can grasp the probability and hence the quantity of information of an actual message ("the negative of its entropy, and the negative logarithm of its probability"), it still says nothing of meaning. Indeed, as Wiener explains:

[277] Wiener, N. (1989), 21.
[278] Ibid., 14.
[279] Shannon, C. E. and Weaver, W. (1964), 16.

> information must not be confused with meaning. In fact, two messages, one of which is heavily loaded with meaning and the other of which is pure nonsense, can be exactly equivalent, from the present viewpoint, as regards information.[280]

Simondon's proposition for a move "From information to meaning [*signification*]",[281] then, puts him at odds with probabilistic theories such as Shannon's and Wiener's. Indeed, whilst the problem of the absence of meaning was noted very early on, it was not resolved from within those theories.[282]

In this regard, when Simondon proposes that an information signal cannot be entirely new, this does not mean that it is already given as a possibility (with a value) from a total set. Instead, his point is that in order to be received, an information signal must have been in some sense predicted or anticipated by the receiver. In order for a signal to be meaningful or effective, it must be compatible with a receiving device. A receiver, then, must have an "aptitude" the kind of information signal in question. Thus, he writes: "It is important to indicate that this relational aptitude is attached to the schema of predictability of information signals".[283] Indeed, if an information signal is incompatible with a receiver, nothing will be received and there can be no relation of information. An aptitude or capacity to receive particular kinds of signals is required for a relation of information, or better, of meaning or effectiveness. Thus, an aptitude is another way of describing compatibility between signal and receiver.

Disparity: compatible difference

Compatibility is not the only requirement, however. Difference is also required for meaning or effectiveness, Simondon contends. If there is no difference, there will be no information. Equally, this difference or novelty cannot be too great, otherwise it will be incompatible and ultimately rendered insignificant. In order to express this mediation

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[280] Ibid., 8.
[281] Simondon, G. (2013), 219.
[282] For example, in his essay in *Mathematical Theory of Communication* Weaver suggests that there are three levels of a general communication problem: first, the accuracy of the transmission of symbols; second, the precision of those symbols in conveying a desired meaning; third, the effectiveness of the received meaning in affecting "conduct in the desired way". Ibid., 24. He recognises, in this sense, that probabilistic theories only deal with the first, framing his exegetical paper as an attempt to offer a resolution to the problem of integrating the second and third levels (of meaning and effect), into Shannon's theory. Rather disappointingly, however, he concludes merely that they are all intertwined since the first (accuracy) is necessary for the latter two.
[283] Ibid., 222.

between compatibility and difference, Simondon uses the example of the "disparity" between the retinae of right and left right eyes in depth perception and the synchronisation of oscillators.

In order for the images received by left and right retinae to produce depth perception they cannot be identical; this would render only a single image without depth. Rather, there must be some difference or "disparity" between the two images received. The two images cannot be too different (or indeed entirely incompatible), however, as this would not give a single image with depth of field, but two separate images, superimposed or in montage. Thus, Simondon writes that

> a disparity must exist between a form already contained in the receiver and an information signal brought from the exterior. If the disparity is null, the signal corresponds to the form exactly, and the information is null as a modification of the state of the system. On the contrary, the more the disparity augments, the more information augments, but only up to a certain point, as beyond certain limits, dependent on characteristics of the receiving system, the information abruptly becomes null.[284]

There must be a disparity between the receiver and the signal, then, otherwise there will be no difference or information. The greater the disparity, the greater the information. If the threshold beyond which there is no longer compatibility between receiver and signal is crossed, however, there will be no information. As we have said, if two images from the left and right retinae share nothing in common, they cannot be used in conjunction for depth perception. Disparity, then, describes a difference between signal and receiver (two images in Simondon's example), or whatever exceeds what they share. The intensity of this difference may augment or diminish, but is nullified if the two images share nothing, or if they are too different. Disparity is thus the compatible difference between signal and receiver. If a signal is entirely different, it will not be received, and there will be no information.

Simondon also uses the example of the synchronisation of two oscillators. This requires that the two oscillating frequencies differ - if not there will be no phase difference, no

[284] Simondon, G. (2013), 222.

disparity and no information. But equally, the disparity of oscillating frequency must not be too great, as it will not be compatible: if it is "too different from the local frequency, there is no longer any synchronisation", and again, there will be no relation and no information.[285]

Visual disparity and synchronised oscillators are, of course, quite specific examples, but Simondon is nonetheless consciously attempting to achieve a very general description with his conception of disparity.[286] The generality of this conception is given by dint of the fact that disparity (compatibility and difference) between receiver and signal is required for any relation of information. We could, for example, apply this description to Simondon's own discussion of brickmaking, and his emphasis on the sense in which clay and a form must be prepared in order to make both compatible with one another. We cannot put sand into a mould to make a brick, as "one will get a pile of sand, and not a brick".[287] Sand cannot receive the information signal sent by the form. Equally, if we put a hard, parallelepiped object into a brick-mould, there is no difference or disparity, and thus no process of information. As Simondon demonstrates, the operation of brickmaking requires two operations which prepare both mould and clay in order that they are compatible, or so that something can be communicated.[288]

The final part of the section, "from information to meaning", summarises this argument in a conceptual redefinition:

> We can name *signal* what is transmitted, *form* that relative to which the signal is received in the receiver, and *information* properly speaking that which is effectively integrated into the functioning of the receiver after the test [*épreuve*] of disparity involving the extrinsic signal and the intrinsic form.

[285] Ibid., 223.
[286] In this respect, Simondon opens the section with a reflection on the possible universality of information for the physical, vital and psychic, that is, as a notion "valuable for thinking individuation in physical nature as much as in living nature, and then, in order to define the internal differentiation of the living being which prolongs its individuation in separating vital functions into physiological and psychic". Ibid., 219.
[287] Ibid., 40.
[288] Ibid., 39-48.

A “signal” is received by a “form”, and as we have been emphasising, signal and form must be compatible but also disparate or different enough in order that there is information.

Stepping back for moment, we might reflect on the relationship between these conditions for the possibility of information - compatibility and difference, or simply, disparity - and the definition of information which we discussed in the previous chapter, in operations command and control. Simondon’s articulation of information as an operation of command emphasises a different aspect of information to disparity, namely, that of an act or expression, and he makes little attempt to explain the consistency and concordance between his reflections earlier in the text and those which we have just discussed. Nonetheless, one must not forget that, for Simondon, an operation of command requires an energetic relation, which in turn, both requires compatibility and difference, or disparity. Sources of energy are innumerable, but they are only accessible with particular capacities - plants are able to receive energy from solar radiation, whilst most other living beings cannot, for example. Difference is also a crucial aspect of available energy or thermodynamic work, expressed most clearly, perhaps, by the sense in which thermodynamic equilibrium describes a state in which differences within a system have been nullified. The role of Maxwell’s demon, for example, is precisely to distribute molecules in a system in order to produce and maintain internal difference, and thus, available energy. Thermodynamic equilibrium and the unavailability of energy - and thus the impossibility of transduction - both describe an absence of difference within a system or in an individual-milieu relation.

Information in operations of control is more self-evident. Compatibility is clearly required for homeostasis to the extent that only certain signals from a milieu are received as information used in operations of control or regulation. Different beings enjoy different receptive capacities, and thus have different “experiences” and different worlds. As we discussed in chapter one, Uexküll neatly encapsulates both the sense in which the different receptive capacities of living beings are used for orientation, but also the sense in which the worlds of different beings are differently constituted by these different capacities. An information signal sent by one plant and received by another, for example, may be crucial for the latter, but insignificant for an animal in the vicinity, or indeed entirely incompatible with their receptive capacities. Difference or

disparity is equally significant, since an identical signal or message offers no further information for control, indeed, some novelty is required for acts of control.

In terms of the argument of this chapter, Simondon's articulation of disparity as compatible difference offers important insight into his conception of limitation or predetermination. We have seen that he is critical of the absolute pre-givenness of the constituted individual, singular characteristics contained in advance by the power of a principle and the concomitant insignificance of genesis proper. Equally, we have seen that the indeterminate temporality or duration of transductive individuation is incompatible with mechanistic and radical finalist principles of time. In this light, then, we presented the preindividual as a source of indeterminacy which drives the duration of individuation and renders the individuated or constituted individual impossible with respect to transductive beings. Finally, the preindividual is always a marginal indeterminacy, limited or constrained in advance by what is necessarily given in advance.

It is in this sense of the limited or given in advance that our discussion of disparity and compatibility is important. Disparity, as we have emphasised, expresses the sense in which difference must be compatible in order for a relation or information to be possible. If signal and receiver are incompatible or if difference is too great, then transductive relation and thus also transductive individuation is impossible. Although compatibility as a condition for relation may seem obvious or banal, it is merely the most general expression of natural necessity. As we will see, the less obvious or more interesting aspect of this is the sense in which necessity and compatibilities can be expressed, determined or predicted, and indeed exemplified. As we will argue, this expression is the work of scientific thinking and technics.

Before we turn to that, however, first we ought to note that our reading of disparity provides a significant rejoinder to Alberto Toscano's reading of Simondon, which brings disparity (which he renders "disparation") to the fore, going so far as to read the preindividual as fundamentally disparate. Toscano certainly makes an interesting proposition, presenting preindividual nature as difference or a problematic field awaiting relation or resolution. The problem with his reading, however, is that he presents disparity as pure difference, thus failing to reckon with the sense in which it

must also be compatible. Thus, Toscano pushes the meaning of disparity beyond its limit, in Simondon's text, if not more generally.

Working with one of Muriel Combes' glosses on preindividuality, which presents it as harbouring incompatible potentials, Toscano expresses disparity as "incompatibility".[289] He thus equates disparity and incompatibility, presenting both as an *absence* of relation. He writes thus, of "the 'non-relation' of disparation, defining the energetic and material tensions between incompatible tendencies within being"; and contends that "relation is framed by the passage from disparateness or incompatibility to relative systemic consistency".[290] Non-relation may be a reasonable way in which to describe preindividuality, since it is *pre*-individuation, which as we know, is precisely a (transductive) relation. To define "disparation" as both "non-relation" and "incompatibility", however, and to identify the preindividual with both terms seems to bear little resemblance to the discussion of disparity we find in Simondon's text.

Perhaps most clearly, Toscano writes that "(preindividual) being is defined as affected by disparation, that is, by the tension between incompatible – as yet unrelated – dimensions or potentials in being."[291] Thus, he reads "disparation" as a "tension between incompatible" aspects of being. With a spirit of generosity towards this reading we might maintain that any difference, whether compatible or incompatible, might be described as disparate - even if, as we have discussed, there will be no information and no relation when it comes to those which are incompatible. Further, Toscano's point seems to be that the preindividual is not just a store of relations and beings waiting to be made extant (a sort of crude Aristotelian potentiality and actuality), which is certainly correct. But this leads to rather a vague understanding of preindividuality and individuality, such that compatibility or limitation (or possibility and impossibility) are never reckoned with. This is clear from the fact that in his gloss "incompatible" is equated with "as yet unrelated". If it were the case that the as yet unrelated were

[289] Toscano ultimately relies on Combes' reading, from which he cites the following: "Preindividual being and, in a general way, every system that finds itself in a metastable state, contains potentials which, because they belong to heterogeneous dimensions of being, are incompatible." Cited in: Toscano, A. (2006), 138; from the original: Combes, M. (2013), 4.
[290] Toscano, A. (2006), 140.
[291] Ibid., 139.

incompatible, then this would render compatible beings only those which are actually in relation, which would empty "compatible" and "incompatible" of any useful meaning.

Simondon's emphasis on the limits of information are thus left unmentioned in Toscano's reading, which expresses disparity (effectively to the contrary of Simondon's text), as incompatibility. This means that preindividual nature appears to be a power able to overcome its own incompatibility.

Failing to reckon with the limitation that the compatibility of disparity places on difference and individuation is not merely a blind spot in Toscano's reading of Simondon. Rather, it has wider implications to the extent that it implies that prediction, regarding genesis or individuation is seemingly ignored, or rendered impossible. In this regard, he argues that since probabilistic theories of information attempt to articulate the totality of the possible in a quasi-atomic manner, they are incompatible with the essentially differential nature of being. This is a perfectly acceptable argument, at least in Simondon's terms. The problem, however, is that from this critique of the atomism of probability, he side-steps whether or not there are any limits or laws before an individuation. Thus, Toscano argues that prior to individuation "it is senseless to speak of the denumerable possibilities" of probabilistic information theory, but concludes that

> it is the processes of individuation that retroactively provide the distinctions which possibility and probability demand, not the latter which supply the parameters within which ontogenesis takes place.[292]

However, if processes of individuation retroactively offer distinctions or beings which may be given probabilistic values, or if some individuations, at least, are predictable, then it seems that recognition of the capacity of concepts such as probability and possibility are necessary. (Indeed, despite Toscano's Deleuzian inclination, here he seems to forget the significance of repetition).

Ultimately, the primary issue with Toscano's reading is that it leaves determinacy, or the limitations placed on preindividual energy entirely to one side. It moves from a critique of information theory directly to the extremely general parameters of preindividuality and individuation without recognising that examples for actual

[292] Ibid., 144.

individuations make this passage possible. He thus argues that the two "conditions" for creative information are "a metastable or problematic field of preindividual being" and a structural germ which resolves a disparity.[293] Rather than including any other limitation or compatibility, however, information is simply rendered "a pure event".[294] This involves an ironically formal reading of *L'individuation*, ignoring the sense in which the content for its transductions is crucial. Whilst a metastable field and a structural seed are indeed required for a crystallisation, for example, *any* field or germ will not do. A crystallisation requires a crystalline liquid and a *compatible* seed.

Simondon's text is full of constraints or limits on the creativity of individuation, expressed by scientific theories and the example beings and environmental conditions they make possible. Transductive beings are singular individuations, no doubt, but they are equally beings compatible with particular conditions of particular milieux which are, to some extent, given in advance. Individuations cannot create any being anyhow, as beings must be compatible with certain conditions - such as sources of energy, for example - in order to continue to individuate, or simply, in order to exist. That transductive beings are substantially relative or depend on relation to a milieu in order to exist can be specified in various ways. Plants require sunlight, whilst different kinds of plant require different kinds of atmospheric conditions in order to individuate and survive, for example.

We might summarise our argumentative thread by means of a question: do some of the limitations, at least, which are necessary for compatibility (and so information and individuation), exist in advance of individuation? The short answer is yes. There are absolute limits on the indeterminate energy of preindividual nature, which are uncrossable with regards to possible relations. The absoluteness of a limit, however, does not equate to absolute determination of an individual or of the time of an individual, such that everything is given in advance. Rather, only something is given in advance, and significant remainder is left for indeterminacy.

Whilst these limits or this determinacy constrains preindividuality, it also makes individuality or individuation possible. This is in contrast to Bergson, who expresses

[293] Ibid., 146.
[294] Ibid.

constraint on the creativity of the *élan vital* by matter or physico-chemical forces as a regrettable fact which life must overcome. Similarly, he describes the repetitiveness of the tendencies of plant and animal as "laziness" on the part of living beings, which would thus seem to prefer an easy life to ceaseless creation.[295] What Bergson does not properly acknowledge, in this sense, is that limitations set on living generation by physico-chemical law both constrain creation but also make it possible. Similarly, plant and animal tendencies, and so too species thereof, are indeed constraints, but they also express the ways in which life becomes compatible with the world and its milieux. Plant and animal tendencies are indeed repetitive, but they also make existence possible. Creations incompatible with the world or a specific environment in which they it finds itself will not be able to exist or indeed endure.

Whilst Simondon may not thematise creation with the patience or subtlety of Bergson, *L'individuation* makes an important contribution to the problematic to the extent that it emphasises mediation between indeterminacy and determinacy. That said, whilst Simondon is clear that the pregiven or predeterminate is both a constraining and a constitutive factor for information, as we have seen, in other respects he does not recognise the full significance of determinacy within his own text. It is thus our own contention that this is what is at stake throughout.

Limits have a double significance in *L'individuation*: first, as real constraints on the creativity of beings, which actual individuations must mediate; and second, constituted by the text itself, through scientific theories and examples, which both constitute and constrain beings as they are expressed therein. We might consider these two aspects of limitation ontological and epistemological, respectively, but this would suggest a naive conception of ontology (as if it were not constituted in part by thinking). Rather, they are better considered two aspects of one ontology, the latter an attempt to understand the constitution of *L'individuation* as thinking or as a text, and equally a reflection on that text informed by a certain doubt. This doubt, however, will have to wait until the following chapter, as it is the former consideration of limitation which we discuss in what follows in this chapter.

[295] Bergson, H. (1941 [1911]), 115 [126 (translation modified)].

In the rest of this chapter, we argue that determinacy is expressed in *L'individuation* according to a necessity external to the individual, or conditions of milieux, and a necessity internal to the individual, or a specific limitation placed on individuation in advance. With regards to the former, we discuss the electromagnetic spectrum, which is a constitutive and limiting factor for the energetic relations of almost every conceivable transductive individual. with regards to the latter, we discuss limitation at the level of the individual, or the sense in which the specificity of reproduction (as Simondon expresses it) constrains indeterminacy in *L'individuation*.

The electromagnetic spectrum: "an immense domain of transductivity"

One of the least read but most fascinating sections of *L'individuation* is that in which Simondon discusses the electromagnetic spectrum. He describes it as "an immense domain of transductivity", whereby transduction or transductivity takes on a double meaning.[296] First, Simondon's discussion of the electromagnetic spectrum is part of a wider discussion in which he argues that scientific research may be inductive, deductive and transductive. In this regard, he argues that whilst James Clark Maxwell made a unifying deduction of the equations which describe electromagnetic radiation, this deduction gives rise to transductive results, to the extent that Maxwell's equations express an infinite horizontal field of radiation, a great field of difference which is only technically divided into species of wave. Second, the electromagnetic spectrum gives expression to the sense in which there are environmental conditions which beings must mediate in order to individuate. In this sense, he discusses the ways in which living and technical beings mediate the electromagnetic spectrum and the extent to which necessary planetary conditions both make possible and constrain individuations.

The electromagnetic spectrum describes the wavelength and frequency range of electromagnetic radiation (which is considered to be the flow of energy at variable wavelength according to classical physics, or the wavelike movement of photons through space according to quantum theory). Wavelength and frequency are measured relative to the speed of light (the constant *c*),[297] whereby the "speed" of wave wriggle relative to *c* describes the frequency of a wave and its length. Electromagnetic waves

[296] Simondon, G. (2013), 119.
[297] This, as Simondon notes, was deduced by James Clerk Maxwell in 1862.

propagate at the same speed (the constant *c*) but their frequency and wavelength differ. This describes, then, the spectrum of continuously variable wavelength and frequency of electromagnetic propagation. Simondon argues thus that whilst we might speak as if there were natural kinds of electromagnetic wave - like X-rays and ultra-violet light, for example - these are technical, scientific or vital divisions. Indeed, these wave regions are properly speaking cut out of the continuity of the electromagnetic spectrum according to the mediating capacities of living or technical beings.[298]

Simondon thus emphasises the fact that some of those regions which are expressed as species of electromagnetic wave overlap or share frequencies with one another. (Such indistinction or overlap between "species" of wave is seen clearly in the diagram below.) At certain frequencies and wavelengths there is an indistinction or overlap between two regions - such as between gamma ray and X-ray, and likewise between X-ray and ultraviolet light. For Simondon this serves to demonstrate that whilst some regions of the spectrum may appear aptly expressed as "species" of wave, they are properly divisions of a continuous spectrum. He thus emphasises what he considers the "transductivity" of the electromagnetic spectrum, to the extent that it extends horizontally rather than vertically (according to the schema: genera, species, individual).

[298] Ibid., 119.

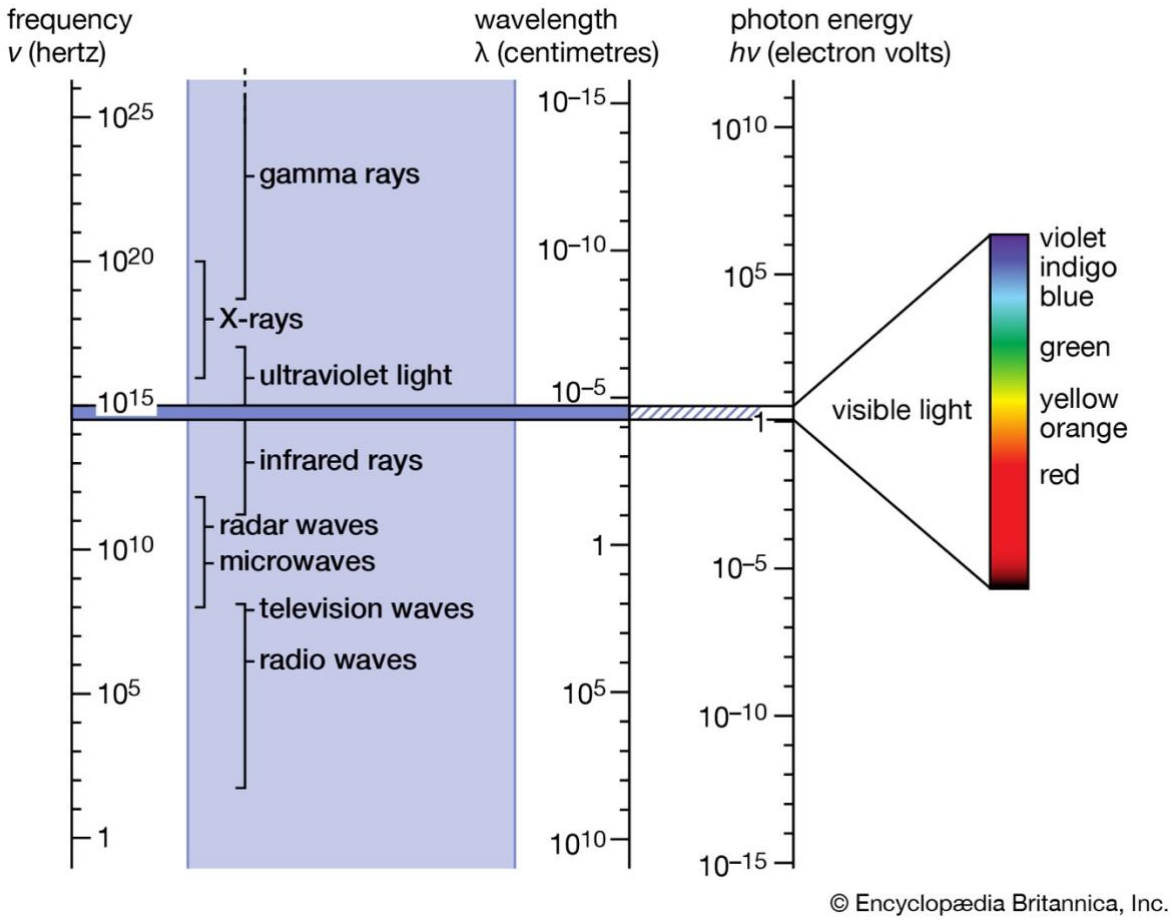

Figure 2. The electromagnetic spectrum.[299]

Although these divisions are not natural kinds of electromagnetic wave, they nonetheless demonstrate something significant about transduction. Indeed, the divisions of the electromagnetic spectrum articulate the ways in which the environmental or planetary necessity of electromagnetic radiation is mediated in different ways, with different results. Thus, the divisions of the electromagnetic spectrum refer to technical capacities for receipt of electromagnetic radiation.

There are numerous examples of the mediation of electromagnetic radiation which we might offer, but Simondon's own are instructive. He explains thus that the range entitled "visible light" is constituted in light of the perceptive capacities of specific living beings. The range called visible light is thus produced from

> the consideration of a living being that perceives; the apparent discontinuity does not come from the continuous scale of electromagnetic wavelengths but

[299] Image available at: https://www.britannica.com/science/electromagnetic-spectrum.

> from the relation between the physiological functions of the living being and these wavelengths.[300]

Thus, whilst the electromagnetic spectrum is a continuous "transductive domain", "visible light" can be cut out of it according to perception, the technical ability or physiological functions of particular living beings. Simondon notes that different eyes, such as those without crystallin (which are common amongst insects), perceive ultra-violet radiation: thus, "bees perceive ultra-violet" whilst birds, for example, do not.[301] Similarly, radio and television waves are functions of technical usage rather than natural discontinuity or species of electromagnetic wave. Simondon thus both stresses the error of determining species of waves rather than vital or technical distinctions, but explains quite carefully why certain frequencies are used for television waves and some for radio waves, and the technical results of these demands.

Pausing for a moment on the implications of the electromagnetic spectrum, we might note that it makes possible and limits almost all of Simondon's work. With regards to his philosophy of technics, the new techniques of radio and television required electromagnetic radiation in order to send and receive information. Equally, if we are correct that his philosophy of transduction is one of information and the conversion of energy, the electromagnetic spectrum plays a fundamental role for the sourcing of energy on earth. Indeed, the sun is the fundamental source of energy for life on earth, which is transmitted as electromagnetic radiation which is received by plants, which then convert (or transduce) it by photosynthesis or biosynthesis. Electromagnetic radiation from the sun is converted into energy for the growth and reproduction of plants and zooplankton (through photosynthesis or biosynthesis respectively), which are the basis of the food chain, and hence, the fundamental source of energy for all other life.

If we return to the terminology of disparity, electromagnetic "signals" cannot be received by any "form", but rather a receiver must be compatible. The nature of electromagnetic radiation thus limits radio or photosynthetic techniques to the extent that in order to receive electromagnetic radiation a receiver must be compatible. This

[300] Simondon, G. (2013), 116.
[301] Ibid.

can be specified further, to the extent that some techniques afford receipt of certain frequencies of electromagnetic radiation whilst excluding other. Thus, whilst mammals broadly receive frequencies within the region we call "visible light", as we have said, bees are capable of receiving "ultra-violet light". Equally, whilst eyes and cameras are able to receive certain frequency ranges of electromagnetic radiation, in Simondon's terminology, ears and microphones (electro-acoustic transducers) receive acoustic waves but not electromagnetic waves.

We can see, then, the extent to which electromagnetic radiation is both constitutive and limiting for living and technical beings. Photosynthesis makes use of electromagnetic radiation, and plants require it in order to exist - it is a condition for the possibility of plants, and beings which depend upon them. Whilst equally, the nature of electromagnetic radiation limits in advance what plants might be and how they can act. Transductive beings require energy to exist and there are limited ways of receiving it; this constrains the creativity of individuation. Photosynthesising plants are possible because of their capacity to receive electromagnetic radiation and they are actual because of the existence of electromagnetic radiation.

Maxwell's expression of electromagnetic radiation demonstrates the extent to which a condition of possibility for the being of living beings is given in advance and is unchanging. This does not absolutely determine the nature of receivers, nor what is sent and received, but it limits or constrains both. This serves as a rejoinder to those who would present preindividuality as an all-creating power. In this context, the choice is thus whether we argue that the preindividual creates the laws of electromagnetism and the beings which mediate it, or whether it is a marginal indeterminate energy which drives the creativity of individuation, which is constrained in advance by the determinacy of electromagnetism. We have defended the latter; first, because it is far closer to Simondon's text - he writes nothing about the preindividual creation of determinacy expressed in scientific laws; and second, because it demonstrates something we take to be more profound, namely, the extent to which individuation is a singular mediation. In this sense, individuation may be creative, but creation is limited in advance, because incompatible individuals will be short lived or unable to exist at all. Scientific, technical and philosophical thinking are in part attempts to work through this interaction between indeterminacy and determinacy. Finally, with regard to Toscano's

presentation of disparity as incompatible difference, we suggest that the difficulty and difference of compatibility is closer to Simondon's text, and a more pertinent problem. Incompatibility, on the other hand, leads immediately or eventually to non-existence or extinction.

If we now return to Simondon's relation to Bergson's work, we note that his position marks a subtle difference to that we find in *Creative Evolution*, in particular, regarding the extent to which there might be general and pre-determined limits on creative energy. This is primarily our own contention, for whilst Simondon refers to Bergson's work on occasion, it is always passing comments. Equally, in these brief reflections, Simondon is seemingly at pains only to distinguish his position from the latter, and the criticisms that he levels at Bergson are cursory and rather underdeveloped.

Regarding the most general limitations on creativity, we contend that Simondon's position makes a subtle reply to Bergson's position. In short, transduction engages with mediation whilst Bergson's *Creative Evolution* emphasises creation to such an extent that he almost forgets the need for mediation and compatibility. In this respect, Simondon emphasises the way in which the determinate or the necessary not only limits and constrains singularity but also makes it possible, whilst Bergson tends to present this as a regrettable fact, or something which the *élan vital* has "overcome".

It can be difficult, reading *Creative Evolution,* to grasp the role that Bergson assigns to matter. Indeed, a quick reading might lead one to believe that when he writes of the "the continual elaboration of the absolutely new",[302] this means that Bergson considers the energy of the *élan vital* somehow unlimited. But this is not the case, as matter necessarily limits any creative energy. More significantly, it is hard to ascertain whether matter determines or orientates creation - by canalising creative energy, for example - or whether it is something which has been overcome by life.

Bergson argues thus that without material resistance, life's evolutionary course would have been like a single course, but in actuality, relative to matter, it has been an explosive, multiple and complex movement. He offers two images of explosion, a cannon

[302] Bergson, H. (1941 [1911]), 11 [14].

ball and a shell; a ball shot from a cannon takes a single course, but when a shell explodes

> the particular way it breaks is explained both by the explosive force of the powder it contains and by the resistance of the metal. So of the way life breaks into individuals and species. It depends, we think, on two series of causes: the resistance life meets from inert matter, and the explosive force due to an unstable equilibrium of tendencies which life bears within itself.[303]

It could hardly be clearer that creative energy is limited and orientated by matter. Life, undivided and whole, is forced to divide into genera and species by the resistance of inert matter.

That life is forced into an actual and specific multiplicity does not mean that virtually, or without material resistance it would be a simple One. Indeed, in the passage above, Bergson writes that life's unstable equilibrium harbours a plurality of "tendencies", intimating both the discussion of vital tendencies of the plant and the animal and the sense in which life is described as "virtually multiple".[304] Somewhat in spite of the image of a cannonball, the point seems to be that life is multiple without material resistance (it is virtually multiple), but its actualisation is both multiple and to some extent determined or orientated by matter.

Whilst matter is clearly a determinant factor for the actualisation of life's creative energy, it is presented as a regrettable opponent to life's desire for indeterminacy rather than a constitutive and necessary factor for actual life. Bergson thus presents matter as a largely vanquished resistance, rather than a condition of possibility:

> The resistance of inert matter [*la matière brute*] was the first obstacle that life had to get around [*qu'il fallut tourner*]. Life seems to have succeeded in this by dint of humility, by making itself very small and insinuating, bending to physical and chemical forces, consenting even to go a part of the way with them, like the switch that adopts for a while the direction of the rail that it wants to leave.[305]

[303] Bergson, H. (1941 [1911]) 99 [109] (translation modified).
[304] Ibid., 259 [282].
[305] Ibid., 100 [110] (translation modified).

Mediation thus seems absent from Bergson's description of life as an energy antagonistic to matter. Indeed, whilst the first sentence suggests that life has escaped or exceeded material determination as an obstacle overcome, those which follow make plain that life is constrained by these forces: "bending to" and "going a part of the way" with physical and chemical forces (here, as elsewhere, matter and physical and chemical forces are run into one another). Whilst material or chemical and physical forces are no doubt limits which cannot be exceeded, for Bergson, they are nonetheless obstacles for life. Thus, life attempts to get around them even if they cannot be overcome.

What is strange about this description is that the *élan vital* does not seem to desire actual life, existence or survival, which instead appear an almost regrettable fact, a necessity which must be accepted or which the *élan vital* must get around. In this sense, as we mentioned earlier, Bergson describes species and tendencies as "laziness" on the part of living beings, where life becomes "relatively stable" and its true impulse grinds almost to a halt.[306] Without any actual living beings, however, there would be no life to speak of. Equally, we might suggest that a desire to survive and reproduce as species or groups - which Bergson sees as idleness - may be a very significant, if not necessary aspect of the existence of creative life. Bergson's desire, in this way, seems to be life distilled from its combination with matter. This would be to forget, however, that as a creative impulse, life must actually exist.

In contrast, Simondon's presentation of physical and vital individuation emphasises mediation, and so too the actual existence, or individuation of beings. In this sense, whilst it is unfortunate that preindividuality is left rather obscure and underexamined in his work, this also emphasises the extent to which actuality or actualising is at the heart of Simondon's text. Preindividuality is, in this way, an indeterminate remainder or margin which drives individuation, prevents constitution and makes absolute prediction impossible. Beyond this, however, the preindividual is not an energy that we could purify or grasp in-itself. Rather, it is only significant in its relation to the mediation which is individuation, which takes place between indeterminacy and the determinate.

[306] Bergson, H. (1941 [1911]), 129; 115 [126 (translation modified); 141].

The singularity of life exists at the level of its duration, for both Bergson and Simondon, but whilst the former argues that life is also connected as a virtual whole in ontological contrast to matter, for Simondon singularity is individual. Whilst Simondon argues that transindividuality is possible, his point is not that every individuation is interconnected in a single embrace, or that preindividual nature forms a whole that is only incompletely divided as individuations. Rather, individuations are discontinuous, for Simondon, who makes no attempt to purify indeterminacy as a single impulse.

Perhaps the clearest absence of the thinking of mediation, in *Creative Evolution*, is Bergson's reasoning for the convergent evolution of organs such as the eye across diverse living beings, which he argues is the result of the unity of the *élan vital*. He proposes thus that the identity of the eye could not be a result of a chance accumulation (a position he attributes to Darwinism), nor a positive effect of the environment, whereby light would actively inform matter, producing organs such as the eye (which he attributes to neo-Lamarckism).[307] Rather, he explains the identity of eyes across different living beings as a result of a "common impetus", namely, the *élan vital*.[308] Thus, although Bergson accepts that adaptation to environments is necessary, he does not suggest that environmental factors may limit or constrain life's actualisations without actively determining them (in this case into the repeated formation of eyes).

Reflecting on this moment in *Creative Evolution*, Keith Ansell Pearson argues (*contra* Bergson) that the convergence of organs like the eye may result from the limited possible ways in which functions might be fulfilled, rather than the unity of the *élan vital*.[309] To put it another way, living creations compatible with conditions of a milieu are more likely to be repeated, as they make existence and reproduction both possible and more likely.

Our reading of Simondon has emphasised something similar. Indeed, the nature of electromagnetic radiation is such that there are limited ways that its energy can be converted for orientation or meaning, in Simondon's terminology. Electromagnetic signals must be received by a compatible "form" such as an eye, which for most human beings, functions within the frequency region we call "visible light". Similarly, there may

[307] Bergson, H. (1941 [1911]).
[308] Bergson, H. (1941 [1911]), 89 [98].
[309] Ansell Pearson, K. (2002), 92-3.

be limited ways in which energy may be sourced for existence, which might explain the convergence of photosynthesising chloroplasts or plasma membranes, in plants and bacteria respectively, and the bio-chemical synthesis involved in the combustion of foodstuffs which we discussed in the first chapter. Whilst Bergson accepts that life is everywhere "a limited force",[310] he does not fully accept the extent to which actual living beings are mediations, and in turn that virtual life requires actual beings. Simondon makes little attempt to think preindividual *qua* preindividual, but rather thinks the mediation of indeterminacy and determinacy (such as the laws of electromagnetism). Individuation *is* this middle moment, the durational mediation between indeterminacy and determinacy.

Matter, in *Creative Evolution*, has a role which is functionally equivalent to the most general limitations which Simondon presents in *L'individuation*. It thus describes the totality of limitations of which the electromagnetic spectrum would be one aspect. The key difference, then, is that whilst Simondon emphasises compatibility and limitation, expressing individuation as a creative mediation, Bergson presents matter as a regrettable necessity for the existence of life, the true creativity of which exists only at the level of a virtual whole. Ultimately, this boils down to the fact that for Simondon (non-technical) singularity exists at the level of the individual, as an actual individuation, whilst for Bergson it is at the level of the virtual whole, the *élan vital*.

Examples: the specific limits of transductive individuation

Up to this point, we have discussed the sense in which conditions external to individuals limit individual capacities. The electromagnetic spectrum provides one example of these conditions, whilst eyes, chloroplasts and plasma membranes provide examples of compatible organs with the capacity for receptive transduction, or conversions of energy. But we have not fully discussed beings as wholes, that is, transductive individuals which might incorporate a variety of transductive capacities. In one sense this would be impossible for Simondon, because we could not discuss the nature of an individual-to-come unless we invoked a principle of individuation. In another sense,

[310] Bergson, H. (1941 [1911]), 127 [140].

however, there is *something* that we can predict about the wholeness of a being, or the specific limitations placed on transductive individuation in advance.

Ostensibly, discussion of genera and species is incorrect when it comes to transduction. As we discussed in chapter one in particular, Simondon argues that transduction is an attempt to grasp the nature of individuation shared by all beings without using hierarchical categories of genera and species. His argument pertains to the transductive individuation of beings, that is, to a transductivity which they all share equally, and not to categorial differences. To move through categories of being from genus, through species to an *infima species,* bridging the final gulf to reach the individual through a principle is, as we have seen, a grave error, for Simondon.

Nonetheless, we contend that his conception of individuation requires and makes use of specific categories of beings (as well specific organs or capacities) in order to express transductive individuation. These specific categories are given by the examples throughout *L'individuation*. When Simondon describes the crystallising individual, for example, the individuality or individuation of *a* crystallising being is not expressed (indeed, this would not be possible). Rather, this description of crystallising beings involves a specific description of crystallisations which demarcate the limits within which a singular individuation can and must take place. Crystallisations are alike in various different ways - they require the same range of atmospheric conditions, available energy, for example - whilst crystals are very effectively specified according to symmetry groups. This is precisely the work of the science of crystallography, on which Simondon's text rests (as we discuss in the following chapter). A crystallisation *qua* individuation cannot be predicted in its singularity, but its specific constraints can be predicted. It is this thinking that affords Simondon's discussion and graphic representation of the conditions for crystallisation (depicted in figure 1 in the previous chapter), and his acknowledgement of the systematicity of (crystallised) crystals.

Ultimately, the singularity of individuation in *L'individuation* is limited in advance by specific descriptions, given almost entirely by the natural sciences. Examples such as crystallisation, the generation of freshwater hydra, mammalian birth and life, to name a few, are all given by a description which precedes the text and which contains or restricts what is left indeterminate. A crystal cannot be anything whatsoever, but

nonetheless the descriptions of crystals in *L'individuation* or elsewhere cannot give the singularity of a being, or all of its characteristics in advance. The descriptions of transductive individuations in *L'individuation* may find what is shared amongst beings - namely, their durational transductive individuating - but this is constrained in advance by the specific descriptions which give these beings as examples.

This may only be a surprise in light of Bergson's and Deleuze's work, both of which attempt to move beyond the confines of specific form as limits on creativity or difference. But, whilst both Bergson and Deleuze acknowledge specific categories whilst attempting to render them partial descriptions of the real, Simondon has no such argument. Indeed, Bergson argues that everyday and scientific human thinking explain self-identical categories which obscure duration and creativity. The identical units of time or the closed systems of science, for example, may serve a necessary technical function, but they also obscure the true continuous creativity of duration. Deleuze produces his own version of this explanation through his concepts of "bare" and "clothed" repetitions, or those which abstract only what is general and identical and those which are differential and make the former possible.[311] Simondon does not have a functional equivalent which would explain specific categories, and whilst he attempts to think individuation free from principles, he is less critical of form than his introduction might suggest.

We contend that Simondon's engagement with natural scientific thinking serves to illuminate and emphasise the Bergsonian choice between the discontinuous specificities of science, on the one hand, and the continuous durational singularity of the *élan vital*, on the other. Whilst Simondon does not acknowledge it, scientific thinking is the condition for the possibility of transductive individuation in his text. These scientific descriptions both make possible but also constrain the creativity of individuations, limiting them to singularity *within* the specific. As we discuss at length in the following chapter, if Simondon is on one side of the Bergsonian divide, Deleuze's thinking has a more indeterminate position, both apparently made possible by scientific thinking, but also resistant of its constraining effects.

[311] Deleuze, G. (1968 [1994]), 114 [84].

In this light, what is perhaps most surprising is that in *L'individuation* Simondon does not think what would be - in profound contrast to Deleuze's argument - the greatest creative difference, namely, the generation of a new species. We could equally describe this as the generation of an absolutely new example, a new kind of being which would produce "analogues", as Simondon puts it, which would individuate *within* their specific or exemplary constraints. In part, this results from the startling absence of living evolution from Simondon's text, including both Darwinian and Mendelian variants. But this also results from Simondon's determinedly non-categorial expression of transduction. In conjunction with his rather partial engagement with other philosophers (such as Aristotle and Bergson) this leads to the failure to recognise this problem. Ironically, then, whilst Simondon attempts to avoid generic and specific categories, they are snuck into his ontology, seemingly without his noticing, through the scientific descriptions and examples on which it rests.

Finally, it is worth briefly noting that this irony is somewhat intensified if we consider that the technical ontology laid out in *Du mode* engages in a lengthy discussion of the species-evolution of technical objects. In this way, the "Genesis and evolution of technical objects", described in the first chapter of *Du mode*, expresses both the "absolute" genesis of a new species or "lineage" of technical beings, and also its development or improvement as or within that lineage.[312] The latter is what Simondon calls the "concretisation" of technical objects, which involves the improvement or perfection of the technical objects which make up a lineage. In each instantiation of a technical lineage, the parts of technical objects are further integrated with their milieu and with one another (becoming functionally overdetermined). In this way, internal combustion engines and vacuum tubes are "concretised" or perfected as each new species of engine or tube is invented.[313]

In this way, the description of technical genesis in *Du mode* excludes transductive individuation as it appears in *L'individuation*. First, to the extent that technical beings are not genetic *qua* individual, but *qua* species.[314] Second, Simondon does not have a

[312] Simondon, G. (2012 [2017]), 21-102 [25-82].
[313] Ibid., 21-32 [25-32].
[314] Equally, as we said in chapter one, they are not negentropic *qua* individual, though they might have external negentropic effects.

conception of the singularity or uniqueness of technical objects, which are instead effectively mere instances of a specific form - such as a Lee Forest triode.[315]

Instead of individuation, then, the genesis of technical objects describes the genesis of a technical species. This phylogenesis includes both the invention of a new lineage (such as vacuum tubes), and more minor inventions or developments within a lineage (such as diode, triode, pentode, tetrode, for example) and inventions within those, with the invention of sub-species (such as the Lee Forest triode). Unlike transductive individuation, then, technical genesis describes the invention of a species of technical object, and its perfection or "concretisation". This further emphasises the sense in which the individuations described in *L'individuation* are constrained by examples. There is no sense in which a crystallisation may evolve specifically, which is perhaps unsurprising, but nor is there any mention of the sense in which living beings might do so, which is a crucial tenet for contemporary biological thinking. In *Du mode,* on the contrary, although generation is tethered to human inventors, novelty is both constrained to the interiority of a species or lineage, but also capable of producing an entirely new species.

Conclusion

Pursuing the theme of singularity, we have explored the sense in which transductive individuation describes a temporally singular individuating being, which is partly open to an indeterminate energy and partly limited in advance. In this regard, the preindividual is not an omnipotent all-creating source, but a marginal indeterminacy relative to individuals. In turn, individuals relate to or mediate the determinate, and so they must, in order to exist. Transductive individuation happens between the indeterminate energy of the preindividual and the necessity of milieux. Individuation is an actual conjunction or mediation between the indeterminate and the determinate; a transductive individual is thus both creative, but also constrained or indeed, partially given in advance.

[315] Indeed, these objects are industrially produced, and any uniqueness or singularity (baring numerical distinction) would be an error in production; it is in this respect, that Simondon is disparaging about the "false novelty" of bespoke technical objects.

More specifically, we argued that Simondon's text attempts to move beyond both principles of individuation and principles of time - mechanism and radical finalism - which absolutely determine beings in advance. Such principles leave no margin for indeterminacy, governing genesis such that everything is given in advance. Similar to Bergson's expression of duration, then, Simondon argues that the temporality of individuation is not predictable in advance. In an inversion of the notion of a principle of individuation, which would give rise to individuality at once, Simondon argues that the true temporality of an individuation *is* its individuality, its uniqueness is its singular duration.

We then discussed the preindividual, criticising the sense in which it has been read as the source for anything and everything, that is, including the laws of nature and all beings. This, we contended, was a partial reading of Simondon's text and also an unedifying proposition. If the preindividual creates everything, then this tells us nothing about beings as they actually are - as Nietzsche recognised, it is a flight from the world as it actually is, into a mystic possibility. In this regard, we argued that the preindividual ought to be read as a relative, marginal or partial indeterminacy. This marginal indeterminacy, we demonstrated, is then fulfilled by Simondon's definition of the conditions of information as disparity. Preindividual indeterminacy must meet determinacy in order for individuation to take place, or for beings to exist. In this way, the determinate limits set on existence or actualisation necessarily constrain the creative energy of the preindividual. This is exemplified in Simondon's work by the electromagnetic spectrum, which both constrains but also makes possible the existence of singular and creative beings. Finally, we proposed that Simondon's examples limit transductive individuation, in *L'individuation* at least, to the specificity of his examples. Rather than emphasising the pure creativity or virtuality of the *élan vital*, then, Simondon's text is centred around the limited actuality of individuations, between the indeterminacy of preindividuality and the determinate limits given by scientific thinking.

Whilst we have emphasised the significance of necessity or determinacy for Simondon's position, then, our focus has primarily been the indeterminacy of the preindividual and the creativity of genesis or individuation. We have thus discussed indeterminacy as a source, but we have only reflected on necessity through the broad structure of

L'individuation and various examples; we have not interrogated the source of necessity for Simondon's transductive philosophy. What we have yet to discuss in detail, then, are the conditions for the possibility of this necessity in Simondon's text, or the knowledge through which it is given - expressed as theories, laws, species and examples. It is this, both the necessity of scientific thinking and the sense in which transduction rests and depends on it, to which we turn in the following and final chapter.

Chapter four - The priority of scientific thought

Almost every text on Simondon's work remarks on his engagement with the natural sciences, and many of those carefully articulate his use and reformulation of concepts

from physics and biology. But very few readers engage with the empirical basis and justification which scientific descriptions provide for *L'individuation*. This chapter attempts to address this lacuna, discussing the empirical scientific foundations for transduction and their broader implications for Simondon's argument.

The first section emphasises the extent to which the empirical, for Simondon, is given primarily by the sciences. In this way, we argue that attempts to justify the empirical priority of transduction are neither textually accurate nor theoretically convincing. Rather, we argue that Simondon accepts the priority of the sciences, including the necessity of induction and deduction for producing transductive descriptions. We go further, however, and argue that a large part of his ontology rests on the veracity of empirical scientific concepts and theories. In this way, Simondon's philosophy moves away from the priority of transcendental consciousness or perception, in such a way that the pre-scientific claim of phenomenology is given up in favour of an ontology founded on the empirical sciences.

The second section of this chapter deals with the nature of this empirical scientific foundation for Simondon's philosophy, arguing that his use of examples throughout *L'individuation* provides the ground for his transductive interpretation. We argue that examples provide the empirical basis, but also limit or constrain the creativity of individuation (as we discussed in the previous chapter) to the interiority of conditions and result, or the virtual and the actual, both of which are given by a scientific description. With this in hand, we discuss the role of the sciences for Deleuze's ontology, and in particular for virtual multiplicities. Indeed, the primary question, following on from our discussion of Simondon's examples, is whether the virtual and its actualisation, as Deleuze expresses it, are not limited by scientific description. In this way, we question whether his alignment of the virtual with structural multiplicities drawn from the sciences, in *Difference and Repetition,* is compatible with his later position, with *Guattari* in *What is Philosophy?*, when the virtual and the actual are distributed and distinguished according to philosophy and the sciences. Both Simondon and Deleuze, then, come up against the difficulty inherent in founding a philosophy of individuation or singular difference on an empirical scientific basis.

In the third part of this chapter, we discuss these difficulties from the empirical-scientific side of the coin. Here we reflect on the doubtful nature of scientific theories, the sense in which they are subject to rectification and falsification. Focussing particularly on Bachelard's argument in *La Connaissance Approchée,* we discuss the sense in which scientific descriptions are themselves moving and subject to constant revision or rectification relative to an always obscure and moving singular reality. For Bachelard, scientific thought is always aberrant relative to a moving singular reality, which he dubs "the detail". The problem, if science comes first and philosophy after, is that philosophy may not be left any means to access the singularity of the "detail". Equally, ontologies such as those of Simondon and Deleuze, in order to illuminate the becoming of beings appear to require an ironically static theoretical ground.

1. Science in *L'individuation*

In the introduction to *L'individuation*, Simondon proposes that individuation cannot be known, but rather it must be thought according to analogy or "a parallel operation", whereby an individuation of thinking reflects an individuation of a being. He writes thus that

> we cannot, in the habitual sense of the term, *know* [*connaître*] *individuation*; we can only individuate, individuate ourselves, and individuate within ourselves, this grasp is thus, at the margins of knowledge properly speaking, an analogy between two operations, which is a certain communication.[316]

If knowledge, in the habitual sense of the term, is an attempt to grasp what is general about beings or processes, then we cannot "know individuation", because this will only grasp what is identical amongst beings, not what is individual. The generic or specific characteristics of individuals or the repetitive aspects of individuations may be known, but this knowledge overlooks what is properly individual. Thus, with this conception of analogy,[317] Simondon offers another option. The "analogy between two operations"

[316] Simondon, G. (2013), 36.
[317] This conception of analogy is like an inversion of the transductive analogy which we discussed in chapter one. The former conception of analogy identifies different operations as transductions across different domains; thus, a crystallisation and the generation of a living being are analogically identified as transductive, for example. This conception of analogy, on the contrary, identifies two operations - an individuation and its identical reflection as an individuation "within ourselves" - it identifies an individuation and its reflection.

above describes the way in which an individuation may communicated without being reduced to something general. Analogy describes the communication between the individuation of a being and an individuation in thought, where thought makes a "parallel" individuation which is a reflection which does not generalise, or remains singular.

That individuation *qua* individuation cannot be known or grasped is unsurprising. From Aristotle onwards, a distinction has been made between the singular and the general, such that sensation is singular and immediate whilst knowledge grasps the general through mediations - like words and concepts - which ignore what is different between sensations, whilst acknowledging and recording what is the same. With this conception of analogy, Simondon is trying to get around both of these options - the immediacy of sensation or the mediate generality of knowledge - proposing that this conception of analogy is a "parallel operation" or individuation which is "not an immediate nor a mediate knowledge of individuation".[318]

We will discuss the difficulties with this conception in a moment, but first, it is worth noting the sense in which it is demonstrative of the problematic of transduction. The problem involves thinking individuations which are other beings, that is, not a relation of sensation, nor another being *qua* generality. Indeed, whilst sensation may be singular or individual, its immediacy is a problem to the extent that it is not a feeling or intuiting another being *qua* another, but rather as one sensation. Transductive beings may exist, in part, as sensations relative to a milieu or other beings, but this sensation describes part of that being, not another individual distinct from it. The immediacy of sensation cannot maintain the distinction between two beings, as sensation or affection *of* another individuation would merely be an extension of an individuation - a psychic individualisation, as Simondon understands it.

The problem with mediation, then, is that it generalises the singular and in so doing excludes the individuality of an individuation. A mediated being may be considered other (alterity may itself be produced by mediation), but it cannot be considered individual. Words and concepts, for example, may mediate the sensible, but in so doing they transform what was singular sensation into the universality of a mediation,

[318] Simondon, G. (2013), 36.

demonstrated clearly, though drawing almost opposing conclusions, by both Hegel and Bergson.[319]

The challenge for Simondon, then, is to think *an* individuation whilst maintaining its separateness from a thinking or feeling being (or individuation) without losing the singularity of the individuating being to a generality. The immediacy of sensation cannot maintain the separateness of two beings, even though it may be singular, whilst mediate knowledge of beings may maintain their distinctness, but it will lose their singularity. With analogy, then, Simondon is attempting (albeit in an enigmatic and rather unfulfilled way) to maintain both the separateness of individuations in question - those of "reality" or "beings" - and an ability to think them *qua* individuation. Thought, for Simondon, can thus individuate as a reflection of an individuation: "only the individuation of thought can…accompany the individuation of beings".[320]

In this regard, we see the extent to which Simondon's problem is different from that of *Creative Evolution*. Since, for Bergson, we are a part of the continuous duration of life, we are able to intuit or feel our continuity or indistinction with the whole of creative life.[321] For Simondon, on the contrary, individuations are discontinuous from one another, hence, analogy is an attempt to retain the discontinuity and the individuality of individuating beings. Whilst for Bergson the problem involves moving to the whole of life from a personal feeling of durational continuity - in part, by recognising the incompleteness of distinctions between living beings - for Simondon the problem is to retain the individuality of a being which is discontinuous or other from the being which thinks or analogically reflects it.

There are two difficulties associated with this particular conception of analogy, however. First, more prosaically, it remains undeveloped in Simondon's text, and he does not discuss the divisions which this conception of analogy attempts to overcome. Divisions such as the relationship between sensation, thinking and external individuations, or between intuition and understanding, or between the "we" in the passage above and transductive individuations remain absent or obscure throughout *L'individuation*. Although we might expect to find some discussion of these divisions and

[319] Hegel, G. W. F. (2018) 60-8; Bergson, H., see for example: (2018 [1944]), 158-162 [173-77].
[320] Ibid.
[321] Bergson, H. (2018), 179 [195].

their proposed analogical synthesis in the section on psychic individuation, we do not. There is no reflection, in *L'individuation* or elsewhere, on the problem of individuation as a problem for thinking or sensation, or a meta-philosophical explanation for the possibility of thinking external individuations as they appear in the text.

The second difficulty is that a large proportion of the text (up until, if not including, the section on psychic individuation) rests on examples of individuations, which are generalisations derived from other generalisations, namely, scientific theories and concepts. This begs the obvious question as to whether it is possible for thinking to co-individuate with a crystallisation or the genesis of a coral, for example, according to an analogical method. This serves to emphasise the extent to which transductive beings are given by theories and concepts derived from natural scientific thinking in Simondon's text. Indeed, the movement of subatomic particles and their mass as a function of their velocity (their transductivity, according to Simondon) are not registered through sensation, nor can they be experienced as such. Equally, although we might have some sensation or experience of a crystallisation,[322] the theories of crystallisation in *L'individuation* are required in advance in order to orientate or make possible the transductive version that Simondon puts forward. In short, a naive or pre-scientific experience of a crystallisation is not enough, scientific thinking is required to make possible the transductive expression and the analogical thinking of a crystallisation.

In this respect, this conception of analogy would have to work with mediations of scientific thinking, producing a rectified or secondary reflection of individuations. In some cases, this seems simply impossible - with regard to sub-atomic particles, for example. In more plausible examples such as crystallisation, it remains difficult to grasp what a reflection of an individuation in thought might amount to (and Simondon offers us little guidance, in this regard). What is significant, however, is that this conception of analogy clearly demonstrates both the sense in which individuations are not sensations, for Simondon; and moreover, the extent to which they depend on prior scientific thinking. It is this relationship of dependence, then, that we intend to explore in this chapter.

[322] Produced by a photo-visual transduction through the medium of electromagnetic radiation, for example.

Induction, deduction, transduction

Just a few pages before this discussion of analogy, Simondon proposes that transduction is unlike induction and deduction to the extent that it does not make generalisations from individuations or impose a form from outside of a domain of being. As he presents it here (in the Introduction to *L'individuation*), then, it appears that transduction has no relation to, nor need for induction and deduction. Readers like Muriel Combes and Alberto Toscano largely follow this presentation, proposing that transduction represents a break from induction and deduction. Transduction is articulated by Toscano as a new "method" which "counters" the induction and deduction as "rival options", whilst Combes proposes that "the study of individuation requires thinking that is neither inductive nor deductive but only transductive".[323] The problem with this reading is that it fails to recognise that Simondon's transductive argument rests on scientific thinking, which in turn, makes use of inductive and deductive methods. Indeed, even if it is indirect, Simondon's articulation of transduction depends on the fruits of inductive and deductive labour.

Simondon's contradistinction between induction and deduction, on the one hand, and transduction, on the other, is brief and oblique, but one can grasp what he is trying to articulate, nonetheless. First, he proposes that unlike deduction, transduction "does not seek a principle from outside in order to resolve the problem of a domain", but rather derives a "resolving structure" from within a domain rather than a "foreign form".[324] Although ambiguous, we might read this as a criticism of the use of equations or principles which result from purely mathematically deductions (that is, outside of a domain in question) in order to explain an individuation in a particular domain. Second, he argues that transduction is unlike induction because the latter conserves only "*what is common* to all the terms, eliminating what is singular".[325] This is more straightforward: whilst induction resolves a problem within the domain in question - it "conserves the characteristics of real terms [*termes de réalité*] included in the domain

[323] Toscano, A. (2006), 152-4. and Combes, M. (2012), 12.
[324] Ibid., 34.
[325] Ibid.

studied"[326] - it generalises empirical data, overlooking the singular for the sake of the general.

If transduction describes individuation in any domain, including thought, then none of this is particularly surprising. If deduction involves imposing a general and external category upon the real, whilst induction concretises what is identical whilst ignoring the singular, then neither of these could hope to adequately think individuation *qua* individuation. Both precisely ignore what is individual, whilst transduction *is* an individuation, whether in thinking or being.

To argue that deduction or induction are inappropriate for thinking transductive individuation, however, is not the same as arguing that they are "rival options"[327] or irrelevant for Simondon's conception of transduction. Equally, whilst Simondon contradistinguishes them in the Introduction, in the main text of *L'individuation* there is a whole sub-section dedicated to the role of induction and deduction in the historical development of quantum mechanics, which is a crucial condition for the possibility of one of Simondon's examples of transduction.[328] Indeed, Simondon precisely emphasises in this section that Maxwell's equations for electromagnetism resulted from, or indeed *are* a mathematical deduction. And, as we saw in the previous chapter, Maxwell's equations make possible the expression of electromagnetism (including the electromagnetic spectrum) which Simondon describes as an "immense domain of transductivity".[329]

More generally, some readers - like Combes and Toscano - counterpose induction, deduction and transduction, proposing that the latter has no relation to the former. We contend, on the contrary, that in *L'individuation*, transduction rests on empirical scientific thinking produced using both inductive and deductive methods. As we will go on to discuss in detail, transduction depends on empirical scientific concepts and theories, which in turn depend on the techniques of induction and deduction.

[326] Ibid.
[327] Toscano, A. (2006), 154.
[328] See the two subsections of part one: *"Le processus déductif*" and *"Le processus inductif"*, Simondon, G. (2014), 112-119 and 119-123.
[329] Simondon, G. (2013), 119.

Adding to the list of terms in a negative definition of transduction, Miguel de Beistegui contrasts phenomenological "reduction" with transduction. In this way, he argues that ontological priority shifts, in Merleau-Ponty's work, from the primacy of the phenomenological to the scientific. Simondon's transduction, for de Beistegui, can be considered an intensification of this development, fully affirming the priority of scientific thought for ontology.

De Beistegui traces this shift in Merleau-Ponty's later engagement with science and his ontology of the "flesh",[330] arguing that the primacy and autonomy of philosophy (as phenomenology) relative to empirical science is inverted. Whilst phenomenology was presented as expressing the conditions for science, or "the science of pre-science", in the development of Merleau-Ponty's thought there is an about-turn, in this regard, such that "the pre-science in question is itself accessible through science alone, and this means through a detailed and demanding confrontation with it."[331] In order for philosophy to reach its proper domain (which is ontology, for de Beistegui), it must thus work with the sciences: the ontological can only be accessed through and after the ontic. If Husserl and Heidegger attempted to defend the priority and independence of philosophy (as phenomenology or ontology) from the empirical sciences, this breaks down in the later work of Merleau-Ponty, and so it should according to de Beistegui. For him, philosophy is ontology, and ontology is now dependent, in part at least, upon empirical scientific thinking.

Recognising that empirical science is necessary for ontology goes along with a rejection of eidetic reduction in favour of nature's "reflection" in the trajectory of Merleau-Ponty's work, for de Beistegui. Phenomenological reduction, which locates transcendental consciousness as the originary condition for being-in-the-world, is given-up in favour of "reflection", which attempts to grasp nature in its genesis and the shared "flesh" of human and world. And with this, the distinction between "life-world" and the "scientific worldview" breaks down. Simondon's transduction is thus read by de Beistegui as an extension of this shift from reduction to reflection. In this sense, transduction involves a movement beyond the perceived to a philosophy which no longer refers to "a horizon of transcendence, but of immanence, in so far as it designates the internal genetic

[330] Merleau-Ponty, M. (1962; 1995).
[331] De Beistegui, M. (2005), 113.

dimension of the phenomenon itself."[332] Transduction thus aims to grasp the genesis internal to a being rather than its conditions of possibility in transcendental consciousness, by means of eidetic reduction.

What is significant about de Beistegui's argument is not any claim for a direct connection or lineage between Merleau-Ponty and Simondon, but rather the claim that they both make a move necessary for contemporary ontology: a shift whereby the priority of phenomenological reduction cedes place to empirical scientific thinking. It is our contention, then, that with this move, one of the principal difficulties for philosophy becomes thinking the nature of the passage from empirical scientific thought to ontology. Whilst de Beistegui makes a convincing diagnosis of post-phenomenological engagement with the sciences, he leaves the transition between scientific thinking and ontology underdetermined.[333] It is the relationship between empirical scientific thinking and transduction which we problematise in this chapter, reflecting on the sense in which the latter depends or rests on the former.

Scientific thinking: inspiration or foundation?

Before we begin our discussion of scientific thinking and transduction in *L'individuation* in earnest, it is worth briefly noting a distinction between our own position and that of another reader of Simondon. Above, we argued briefly that Combes and Toscano both underestimate the significance of induction and deduction for transduction because they do not properly acknowledge the dependence of *L'individuation* on empirical scientific thinking. Jean-Hugues Barthélémy takes a different view, which better appreciates the significance of science for Simondon's work but, we contend, misjudges its role in Simondon's argument. Rather than providing an empirical foundation for Simondon's claims regarding transduction, Barthélémy argues that science merely provides conceptual inspiration for Simondon's properly philosophical innovation.

Barthélémy argues thus that Simondon's engagement with the sciences provides him with a number of "epistemological" concepts for his relational ontology, but not a basic empirical description.[334] In this way, he proposes that Simondon derives concepts of

[332] Ibid., 120.
[333] De Beistegui, M. (2004).
[334] Barthélémy, J.H. (2008), 9.

potential energy, metastability, and a paradigm example from his engagement with thermodynamics and crystallisation, but not empirical justification for the generality of transduction. Most clearly, in this regard, Barthélémy contends that Simondon derives a non-substantial theory of relation from Louis de Broglie's "double-solution" to quantum mechanics, but not any ontological justification regarding quantum individuation.[335] In this sense, Simondon would not defend or gain anything de Broglie's ontological claim, but merely derive conceptual inspiration from his conception of relation.

This, Barthélémy contends, is Simondon's "Bachelardian heritage", which is encapsulated in the "inductive value" of physics, meaning that philosophy might learn conceptual positions from physics.[336] In this way, "philosophical ontology [can] be constructed from what it learns from physics".[337] But what philosophy "learns", according to Barthélémy, is not there are some areas where de Broglie's double-solution is applicable - to subatomic particles - and some where it is not - to crystallisations, living beings, psychic individuations, for example. Instead, this learning amounts to the derivation of broad conceptual inspiration from scientific theories, in the sense that the double-solution would provide some stimulus for Simondon's own innovation, namely, his conception of substantial relation.

To claim that de Broglie's double-solution is the primary inspiration for Simondon's concept of relation is debatable, since the latter conception appears at the beginning of *L'individuation*, long before the discussion of de Broglie, whilst nowhere does Simondon proposes that the double-solution is the key inspiration in this case.

More significantly, however, arguing that science provides mere conceptual inspiration leads Barthélémy to significantly underestimate the sense in which science provides an empirical foundation for Simondon's transductive claims. As Barthélémy reads it, whilst Simondon derives a concept of relation from physics, he makes a "metaphysical" generalisation of it for the purposes of an ontology which unifies the sciences.[338] Thus,

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[335] Ibid., 29-34.
[336] Bachelard makes this argument regarding Einstein's theory of relativity and Barthélémy claims that Simondon uses the same method, both "prolonging" Bachelard's work and using "exactly" his formula in *Le Nouvel Esprit scientifique,* despite a complete lack of textual reason, Simondon making no reference to Bachelard's work. Barthélémy, J.H. (2008), 12.
[337] Ibid., 9.
[338] Ibid., 35.

he contends that Simondon's ontology does not rest on any empirical scientific basis, but instead it is prior to and independent from the sciences:

> Since Simondon's genetic ontology is intended as "first philosophy" and is not entirely reducible to foundation on physical schemata, its ultimate 'basis' [*fondement*] is rather 'metaphysical', or in any case properly philosophical."[339]

Thus, whilst the concepts of Simondon's ontology are inspired by scientific thinking, according to Barthélémy, his ontology is not reducible to concepts from physics. We accept that Simondon's ontology is not reducible to "physical schemata", but it requires a great leap to claim that the "ultimate 'basis'" of *L'individuation* is "metaphysical". Indeed, this ignores all of the example beings which Simondon uses to develop and defend his claim for the generality of transduction. These examples are not metaphysical; rather, they are made possible by empirical scientific thinking.

Transductive beings are not given by sensation, and they are not accessible through the pre-science of phenomenology. Instead, scientific thinking provides expressions of those beings on which Simondon rests his claim that physical and vital beings are transductive individuations. Simondon's argument is justified by the examples which he uses, which are in turn made possible and justified by scientific theories. Transduction is not posited as a metaphysical ground, but rather, it is an attempt to produce a novel conception of individuation based on scientific theories and examples; or, from a different angle, it is a general ontological description which is applicable to the various domains of empirical science (we might remember in this regard, that *L'individuation* is structured according to the physical, vital and psychic). The claim for the universality of transductive individuation, in this sense, should not be regarded as metaphysical. Instead, it is a *hypothesis* which is tested and partially justified or supported by examples (which are themselves confirmed by the empirical sciences), whilst this justification is necessarily partial and subject to doubt. Were Simondon simply positing the generality of ontological relation, it would beg the question as to why he would go on to demonstrate it with scientific theories and examples.

[339] Ibid.

To put it another way, whatever Simondon's claim may be, it is justified in part by its congruity with the description of beings. The claims Simondon makes regarding phases of matter, crystallisation or the electromagnetic spectrum, for example, rely on ontological descriptions made possible by scientific theories and concepts. Simondon's text is justified by its scientific basis. He makes little attempt to explain the nature or justification of that foundation itself, however. Given that this justification is crucial yet merely implicit throughout *L'individuation*, it is part of the following work of this chapter to make this position more explicit. As for Barthélémy's argument, he is correct that Simondon repurposes a number of concepts from scientific theories and concepts, but he underestimates the empirical basis for Simondon's argument; it is to the latter that we now turn.

2. What is an example in *L'individuation*?

In chapter two we demonstrated the importance of examples for Simondon's argument and suggested that they are dependent on proven empirical science (or that which has "proven its mettle") which comes before Simondon's transductive proposition. In chapter three, we discussed the sense in which individuation is limited to an exemplary specificity in *L'individuation*, to the extent that examples both constitute and constrain the creativity of individuation. In this section, then, we attempt to weave together these threads along with what we have just argued regarding the role of scientific thinking for transduction, in order to articulate the role of examples in Simondon's text.

If *L'individuation* is all about individuating beings, then examples would seem to be the antithesis of this ontological description, because they are self-identical and general. An example is not an individuation *qua* individuation, rather, Simondon's examples describe the aspect of an individuation which does not change and which is general to various beings, not something becoming and singular. If an individuation is only accessible by an analogy which reflects an individuation without generalising it, as Simondon argues, examples mediate individuations, withdrawing only what is self-identical and general, whilst overlooking what is durational, or a unique becoming. To put it simply, an individuation *qua* individuation cannot be exemplified. This is perhaps to state the obvious, but it serves to demonstrate the extent to which Simondon's proposition regarding individuation makes use of general mediations throughout.

Indeed, we contend that Simondon's argument depends or rests on these generalities or mediations.

Reflecting on the role of examples distinguishes our line of questioning from anything to do with thinking or intuiting *an* individuation *qua* individuation (the task of analogy, according to Simondon), directing us towards a more general condition for the possibility of thinking transductive individuations. Moreover, it directs us to the scientific conditions for the possibility of Simondon's examples, the conditions for the conditions of *L'individuation.* Indeed, Simondon's text is not an attempt to grasp the nature of a pre-scientific intuition of crystallisation or the generation of protozoa, for example. With no knowledge of the theoretical expression of phases of matter and crystal groups, or the energetic and chemical processes involved in the generation of single celled living beings, for example, their transduction would remain inexpressible. We could not simply look on as these beings came into existence and continued to grow. Rather, prior scientific knowledge makes Simondon's transductive interpretation possible.

Examples themselves do not change in Simondon's text, but they make thinking something which does change possible. If we take the paradigmatic example of crystallisation, we can see that there are three parts to it: first, a supersaturated or "metastable" substance; second, the operation of crystallising or individuating; and third, the crystallised crystal, after individuation is complete. The transductive individuation is the middle part, the crystallising or individuating, and Simondon's primary interest. But in order to grasp the middle moment, a large portion of the section on crystallisation is spent discussing the first and third parts, the conditions and the result.

Scientific thinking provides Simondon with a description which he uses to produce the paradigm example of crystallisation in *L'individuation*. This scientific thinking takes place prior to *L'individuation* and separate from a pre-scientific phenomenological consciousness. This thought also provides a description of crystallisation as a repetitive and predictable process. In this way, the conditions, crystallisation and the crystals which results from a process of crystallisation are not predictable with absolute precision, but they are predictable to a certain degree, or within a certain range of

possibility. It is this predictability which makes the general and unchanging example possible, and it is relative to this self-identity that the unpredictability of an individuation is made manifest in the text.

The conditions for crystallisation, then, are partly predictable and partly unpredictable. Before an actual crystallisation might be thought analogically, Simondon must explain the phase changes of matter, emphasising the relation between phases (liquid, vitreous, gaseous) and energy (temperature and pressure). In chapter two we saw the graph which plots phase changes of matter according to the two variables of pressure and temperature, which are expressed on the *y* and *x* axis respectively. Most important is the region on the graph within which liquid becomes metastable, for that is the range of temperature and pressure within which a liquid of a certain substance may crystallise. With a further figure, Simondon demonstrates the sense in which crystallisation depends on the capacity for crystallisation (the number of crystalline seeds which appear in a given period of time) and the speed of crystallisation. Perhaps more clearly than anywhere else in the text, these graphs serve to express the sense in which various fixed conditions are required for an individuation. The graphic representation of these conditions does not feign exact prediction, but only a certain range or degrees of probability. Simondon's graphs cannot predict the precise pressure and temperature at which a crystallisation will begin, for example, but this is not their function. Rather, they express the specific limitations on the conditions for crystallisation, both what (according to the truth of the graph) is possible and what is impossible,[340] or those conjunctions of temperature and pressure at which crystallisation can and cannot take place. Indeed, there are no numbers on the axes, and thus the graph is not used to present precise limits of crystallisation. Rather, more broadly it demonstrates the fact - according to the science of crystallography and Simondon, at least - that crystallisation

[340] We do not mean, of course, that crystallisation is rendered possible and impossible by the truth claim of this graph. Rather, we mean to emphasise both the sense in which the graph represents an empirically tested claim (verified or which has "proven its mettle") about the conditions which make crystallisation possible and impossible. Although "crystallisation" might be said possible irrespective of scientific knowledge of it, we mean to emphasise that Simondon's own claim regarding the conditions for transduction require that scientific knowledge of crystallisation be true, or at least found plausible by his readers. Simondon's claim is not that the appearance of crystals is a bare fact, but rather that the particular way in which crystallisation happens - expressed by crystallography - is transductive.

is limited and predictable, and that it can be represented approximately in a graph such as this, and it must be for Simondon's argument.

Indeed, it is this fixed and limited structure for the conditions of crystallisation on which, in part, Simondon's example rests, or which makes his example possible. Reading Simondon's text we can thus list the specific conditions for a crystallisation: a particular chemical substance - like piperine or betol - and a particular range of temperature and pressure. The conditions for crystallisation are thus fixed and may be repeated under laboratory conditions. Compatibility and difference (or disparity) are required, as we discussed previously: there must be available energy or an energetic differential - the liquid cannot be at thermodynamic equilibrium - and the available energy or metastability of the liquid requires a seed which is *compatible* in order to initiate crystallisation.

As we have said, these conditions are not available to a pre-scientific or natural consciousness. Rather, scientific thought provides the conditions for the possibility of Simondon's argument, and thus it comes first. The graph describes a fixed set of conditions, according to temperature, pressure and chemical substance. These are not absolute in their precision, and if tested they may be found in fact to err, but for Simondon's text, they are taken as valid and unchanging. The empirical-scientific work of crystallography may, amongst other things, attempt to rectify descriptions such as these, with increasing precision regarding one or more of the variables, but for *L'individuation,* a book rather than an ongoing process of research, the description of these conditions is fixed according to the graphs given. Simondon's argument for crystallisation is made possible by and rests on these descriptions.

The third aspect of the example in Simondon's text is the crystal which results from a crystallisation. Individuated or crystallised crystals are not Simondon's interest, of course, but his argument rests nonetheless on scientific knowledge of crystals. Like their conditions, crystals are in part predictable and in part unpredictable. The interfacial angles of a crystal are predictable relative to the chemical substance from which they are generated (as Simondon notes), whilst their facial angles are unpredictable. The "law of constancy of angles" states that "in all crystals of the same

substance, the angles between corresponding faces have a constant value".[341] To this extent, the science of crystallography has successfully mapped the substance-structure relationship of interfacial angles but ignores the singularity or unpredictability of resultant crystals. As Frank Phillips puts it, the angle, size and shape of the faces of a crystal are thus

> purely incidental features determined merely by the conditions of growth of a particular crystal under consideration, but the angular relationships of these faces reveal the underlying crystallographic symmetry.[342]

The "incidental features determined merely by the conditions of growth" describe the unpredictable aspect of a crystal, whilst the "underlying symmetry" of interfacial angles refers to the general and regular features of actual crystals, which crystallography uses in order to categorise crystals according to symmetry groups.

Whether a (crystallised) crystal is singular or not, it is not transductive and thus not what Simondon is attempting to express, as we discussed in chapter one. What we are instead attempting to demonstrate is the extent to which the scientific knowledge on which Simondon's argument rests works with both conditions for crystallisation and the results in order to articulate the regularity of crystallisation. Crystallography categorises crystals according to symmetry groups, and thus whilst Simondon is not directly interested in individuated crystals, they are indirectly crucial for his argument. The science of crystallography provides the conditions for the possibility of Simondon's argument regarding transduction, and crystallography rests, in part, on knowledge of crystal groups - the predictable result of crystallisation.

The final part of Simondon's example is the transductive individual - the crystallising or the individuating - or the middle moment between conditions and result. We have discussed in previous chapters how this can be thought as durational and unpredictable, and it is this individuating which Simondon proposes "we cannot know, in the normal sense of the word", but we must instead think analogically. This does not mean, however, that there is nothing that can be known "in the normal sense of the word", about a crystallising being. As we argued with regards to induction and

[341] Phillips, F. C. (2011), 13.
[342] Ibid., 18.

deduction, whilst we cannot know the individuality or the individuation of a being, we can nonetheless know *something* about it. It is true that this knowledge is broad, to the extent that we know, for example, that it is a conversion of energy (a transduction), from one form to another. But in another sense, whilst the crystallising moment may be the least knowable or the most singular, this is not to say that it is simply unpredictable. Indeed, conditions and result limit the creative capacity of a crystallisation. Equally, whilst a crystallisation is partly unpredictable (in its temporality or according to the generation of facial angles, for example), in another sense it is quite predictable: its speed and extent can in part be grasped in light of its conditions. In the broadest, but perhaps most intuitive sense, a crystallisation may be singular, but it will likely be unsurprising.

This scientific knowledge, expressed as the graphs for phases of matter and crystallisation or in crystalline symmetry groups, is a condition for the possibility of Simondon's argument for transductive individuation, and equally a constraint on the creativity of transductive individuation. Whilst a crystallisation may be unknowable *qua* individuation, as Simondon argues, its specificity - that it is a crystallisation and not some other kind of generation - *can* be known. The knowledge on which Simondon's argument rests limits transduction, in his text, to specific descriptions, such as crystals, or freshwater hydra, or termites, and so on. Simondon's work implicitly accepts these descriptions to the extent that his thinking is founded on them, and thus they limit the creativity or indeterminacy of individuation. This is like the epistemological mirror of what we argued in the previous chapter: we are now discussing the epistemological conditions for the "natural" conditions and limits on individuation that we discussed previously.

If we think of other examples in *L'individuation*, such as protozoa, termites, sea squirts, or lichen, the same can be said. First, these beings are limited to their example. Whilst Simondon does not discuss their conditions as carefully as with crystallisation, they are generated from conditions which produce a protozoan being or a termite, for example. These beings may differ within this specific description, but they are nonetheless limited or constrained to this description. Second, Simondon's argument is both made possible and constrained by the knowledge which articulates the generation of these beings as such. The descriptions of these geneses are not simply given to a

phenomenological, pre-scientific consciousness, rather they are experiences which have been generalised and rectified by the practice of scientific thinking. These descriptions may err, in which case *L'individuation* will err, and depending on the nature of this error, may be falsified. For the moment we are trying to emphasise the sense in which scientific knowledge both constitutes and confirms Simondon's argument, but also constrains the creativity possibility of transductive individuations. Later in this chapter, then, we will discuss the sense in which the nature of this empirical scientific basis leaves his argument open to rectification and falsification.

This situation should also serve to emphasise perhaps the greatest error and omission from *L'individuation*, namely, biological evolution. In this regard, the specific forms which limit the creativity of individuation, in *L'individuation*, could be expanded, exceeded, or broken by a new kind of being. Even with the addition of a theory of evolution, in a profound sense, the specificity of scientific description would remain. Indeed, a new biological species may be articulated as a collection of instantiable features, or, if one holds that such species are individuals, we could find the identically repetitive genetic core of these trans-temporal individuals, as we discussed in chapter two. It is the specificity of scientific knowledge, then, that constrains the creativity of individuation - and, as we have been arguing, which also constitutes the beings which make possible Simondon's argument.

We have thus seen both the way in which Simondon's argument is made possible by scientific thinking, and the limiting effect that this has on creativity. This draws attention to something of an irony in Simondon's position, in the sense that he criticises genera and species as means for accessing individuation, whilst specific descriptions are a crucial aspect of his argumentation. This has hopefully further illustrated our criticism of Barthélémy, highlighting the sense in which the foundation of Simondon's argument is empirical rather than metaphysical. With this discussion we also see something of the significance of induction and deduction - to which we return in more detail in the third section of this chapter - to the extent that both are required for scientific thinking. Most clearly, perhaps, induction provides justification for the conditions for Simondon's argument.

In response to our question - What is an example in *L'individuation*? - we might now say that an example supplies the predictable limits within which an individuation is unpredictable, or within which individuating takes place. The examples in *L'individuation* predict both the conditions for an individuation and its result or specific form, in the case of living beings. Examples are thus made possible by scientific thinking, and in turn make Simondon's argument for transductive individuation possible. Transduction rests on these examples, which rest on scientific knowledge. This expresses the sense in which scientific thinking, rather than phenomenology, comes first, and philosophy or ontology second, for Simondon.

Virtual multiplicities in light of scientific thought

We now turn to Deleuze's expression of virtuality and actualisation in *Difference and Repetition*, which, we will argue, amounts to an illuminating refinement of Simondon's position, whilst Simondon's text also demonstrates something apparent but underdeveloped in the former.

A number of texts have been written which reflect on Simondon's importance for the development of Deleuze's work, primarily aiming to explicate the latter rather than assessing the former. Anne Sauvagnargues, for example, has convincingly made the case that Simondon's work had a significant influence on that of Deleuze, particularly regarding his conception of modulation. Whilst Sauvagnargues is a very fine reader of Simondon, her texts focus primarily on grasping Simondon as an influence on the development of Deleuze's thought rather than a critical reflection on that of Simondon. Her reading thus closely follows Deleuze's and Guattari's approach to Simondon's work as a resource or a "box of tools", that is, as a selection of relatively disjointed concepts which may be used, rather than a unified project. The reading that we attempt in what follows takes a different route, reflecting on Deleuze's development of Simondon's work and assessing its plausibility; that is, our approach is primarily attempts a critical assessment rather than an interpretation of philosophical influence.[343]

[343] See, for example, Sauvagnargues, A. (2010; 2015). Sean Bowden (2011; 2012) has also made close and scholarly discussion of Simondon's influence on Deleuze, and particularly his *Logic of Sense*, which like Sauvagnargues' work, is primarily focused on grasping Deleuze's texts.

In *Difference and Repetition*, Deleuze makes a significant development of Simondon's position in *L'individuation*, more specifically we are interested in his contention that the conditions for an individuation do not resemble the individuation or the individual. In this way, drawing on both Bergson and Simondon, Deleuze makes a wide-ranging critique of generation in the history of philosophy, most pertinently targeting modality in Aristotelian and Kantian philosophy. And with this, Deleuze re-articulates Simondon's philosophy in such a way as to clarify certain aspects of its broad philosophical implications.

Whilst the philosophical stakes of Deleuze's text may be clearer and more refined than Simondon's text, its presentation of the relationship between the sciences and ontology is left more obscure. In this regard, we can learn something about Deleuze's philosophy from our own discussion of the function of examples in Simondon's work. Indeed, whilst Deleuze argues (correctly, we suggest) that the conditions for a being neither resemble an actualising nor an actualised being, these three aspects of generation are necessarily connected with one another nonetheless. Further, in the relationship between the virtual, actualising and actualised - or as we said for Simondon's argument, conditions, individuation and result - there is a specific constraint placed on the capacity for creativity. This, we argue, is clearly exemplified by Simondon through his close and sustained engagement with scientific thinking, whilst it remains rather oblique in *Difference and Repetition* because it takes more distance from scientific thinking.

At the broadest level, in *Difference and Repetition* Deleuze argues that difference must be thought prior to identity, whilst the function of identity is taken on by repetition which is differential rather than identical. This amounts to an overturning of the priority of identity in categorial ontologies, whereby the identity of a genus or species always takes precedence over the differences between beings under a category.

One of the major aims of *Difference and Repetition*, then, is to produce a concept of difference which can be thought prior to identity. In this sense, difference is not reduced to or constrained by a prior and relative identity - a specific difference - but is considered difference in-itself. Repetition, then, is considered a product of this fundamental difference, but again, repetitions are not identical, but always differential. In this respect, the philosophy of *Difference and Repetition* is also one of generation, and

the concept of difference therein is best expressed as the difference of generation, or indeed differentiation. If repetitions appear to be self-identical, Deleuze argues that this is only at a certain scale, as "bare repetitions"[344] stripped of their differential core. In this regard, one can see the influence of Bergson's work, to the extent that the appearance of the self-identical - whether as time, concepts or language, for example - is precisely the work of the human condition.[345] Deleuze extends Bergson's position, however, proposing that it is not only the living which is differential and creative, but being itself.

The similarities between *Difference and Repetition* and Bergson's and Simondon's work are significant and have been noted on many occasions.[346] Each prioritise becoming or the generative over the already given or self-identical, whether in the form of categories, concepts or principles; whilst temporality considered ontologically singular or unpredictable is key for all three. Our intention here is not to set out a lineage from Bergson, through Simondon to Deleuze, however, or to explain the influences of the former on the latter. Instead, our discussion is primarily technical, focussing first, on the conditions and structure of genesis in Deleuze's text, and second, on the sense in which this may be in conflict with scientific description. In this way, we will discuss the role of virtual multiplicities and their actualisation, reflecting on what they illuminate in terms of Simondon's work.

Whilst Deleuze's articulation of virtual multiplicities and their actualisation is, in one sense, a refinement or development of Simondon's position, in another, Simondon's work serves to demonstrate the problematic relationship between Deleuze's argument and the sciences. The difficulty, simply put, is that if science provides the initial theories and concepts for thinking, then it restricts thinking thereafter to the interiority of self-identical and specific concepts or examples. Our contention, then, is that Deleuze's basic argument in *Difference and Repetition* - that difference is prior to and unconstrained by self-identical concepts - is in tension with the claim that science can provide the

[344] Deleuze, G. (1968 [1994]), 114 [84].
[345] Ansell-Pearson, K. (2007).
[346] See, for example, Ansell-Pearson, K. (1999); (2002); Barthélémy, J.H. (2005a), (2008); Mills, S. (2015); Toscano, A. (2006).

conditions for Deleuze's work. Releasing difference from the constraint of the concepts of scientific thinking, we contend, is to untether it entirely from scientific thinking.

For Deleuze, a virtual multiplicity or an Idea is a condition for the genesis or actualisation of beings. Crucially, a virtual multiplicity does not resemble the beings which it actualises, as potentiality or possibility resemble actuality. Instead, the actualisation of the virtual, for Deleuze, is a creative differentiation which produces a being which does not resemble its condition. Simondon's expression of crystallisation provides a good example in this respect: metastable substance does not resemble the crystallising individuation, or the crystalline phase, but it is its condition, nonetheless.

The problem, according to Deleuze, is the significant tendency in the history of philosophy to explain the genesis of a being according to a condition which resembles what is considered an actual being. In this regard, thinking genesis goes hand in hand with asking the question of "what" a being is - asking about its essence or quiddity. If we know what a being is, then - abbreviating somewhat - we can determine its condition as a transcendent *eidos*, a natural potentiality, or the work of a synthetic transcendental consciousness, for example.[347] More generally, the condition for a certain kind being would thus be its form, which constitutes its essence or quiddity, and matter, which brings it into existence. Rather than thinking genesis proper, according to Deleuze, this merely produces a genetic condition in the image of "what" a being is.

In this way, Deleuze argues that Platonic *eidos*, Aristotle's categorial ontology and his *dunamis* and *energeia* pair, up to the role of possibility in Kant's transcendental concepts are means for thinking genesis which reduces creation to the actualisation of something already given. The self-identity of the concept derived from the question as to the quiddity of a being is a condition for generation but also a constraint on its differentiation - an actual being only differs from its potentiality by dint of existence. If the generation of an animal is explained as the materialisation of animal form; there is no process of differentiation or generation proper, but only the coming-into-existence of a form which already existed in some sense. Platonic forms have an intemporal and causal primacy, whilst even in Aristotle's revision of this, *energeia* comes before *dunamis* in every sense. The thrust of Deleuze's criticism of resemblance can also be

[347] Deleuze, G. (1968 [1994]).

read as a reformulation of Bergson's critique of possibility in the Kantian tradition. In this way, like Bergson, Deleuze argues that if the actual or the real resembles the possible in all but existence, then there is no creativity or difference in generation.[348]

Virtual multiplicities thus *replace* potentiality or possibility in the Aristotelian and Kantian traditions. The crucial difference is that whilst they are conditions for actualisation, they do not resemble beings which are actualised. Whilst the possible is "produced after the fact, as retroactively fabricated in the image of what resembles it",[349] virtual multiplicities are conditions for actualisations and actual beings which do not merely explain beings through a metaphysical power expressed as a mirror for created beings. Rather than metaphysical conditions produced in the shadow of an actual being, virtual multiplicities are real conditions, Deleuze contends. If the possible resembles the actual without being real, virtual multiplicities are fully "real" without being actual.[350]

If it is clear how one arrives at a condition for genesis which resembles the being it creates - namely, by asking what that being is and producing a description of an essence or a form with the response - it is less clear how Deleuze arrives at his description of virtual multiplicities. How, we might ask, do we know that *x* is the condition for *y*? One answer to this question is that empirical science delineates the relationships between virtual conditions and actualisations or actualised beings.[351] In this respect, the similarity with Simondon's position is clear, to the extent that he argues the condition for a crystallisation is not a principle of individuation or a crystal form, but the real conditions he lays out, which he derives from crystallographic theory. A supersaturated liquid and a change in temperature and/or pressure does not resemble a crystallising or crystallised being, but Simondon argues that it is their condition, nonetheless.

Unlike Simondon, however, Deleuze attempts to give a more general definition of the conditions for genesis, or virtual multiplicities, that is, abstracted from particular examples. In this way, Deleuze proposes that there are "three conditions" which allow

[348] Bergson, H. (1969 [2007]), 56-65 [96-112], Deleuze, G. (1968 [1994]), 273-4 [211-12].
[349] Deleuze, G. (1968 [1994])., 273 [212].
[350] Ibid., 272-3 [211].
[351] Texts such as those by Manuel DeLanda (2002) and Miguel de Beistegui (2004) make this kind of argument. Indeed, even if they do not go so far as to argue that science is necessary for Deleuze's argument, they nonetheless propose that it provides significant proof or justification for it.

us to "speak of a multiplicity", or "which together allow us to define the moment at which an Idea emerges".[352] The first condition is that the elements of a multiplicity "have neither sensible form nor conceptual signification". The elements of a virtual multiplicity cannot be grasped according to form or concept, rather they are appreciable only as a multiplicity of elements. We might know that there are plural elements, but we can say little more, since they actualise in ways which do not resemble their virtual nature. Second, these elements do not exist autonomously from one another; instead they determine one another by "reciprocal relations which allow no independence whatsoever to subsist".[353] The elements of a virtual multiplicity, then, are indeterminate in-themselves or in an absence of relation to one another. Third, as we mentioned, a multiplicity or Idea actualises differentially, and indeed variously:

> A multiple ideal connection, a differential *relation*, must be actualised in diverse spatio-temporal *relationships*, at the same time as its *elements* are actually incarnated in a variety of *terms* and forms. The Idea is thus defined as a structure.[354]

The actualisations of a virtual multiplicity, then, are diverse or various, which is to be expected since its actualisations are creative. With this broad description, virtual multiplicities may appear to replace one metaphysics with another. However, Deleuze offers examples from empirical sciences for both virtual multiplicities and their actualisations.

Deleuze gives three examples of virtual multiplicities in *Difference and Repetition*: atomism, the organism, and social Ideas. They are listed according to the division of the natural sciences, as "physical Idea", "biological Idea" and "social Ideas, in a Marxist sense" (and the latter, the least *natural* scientific, is identified with Louis Althusser's decidedly natural scientific Marxism).[355] We will focus on the first two, but first it is worth noting that Deleuze does not straightforwardly affirm these examples. Rather, he offers them as partially successful expressions of his conception of virtual multiplicities,

[352] Ibid., 237 [183].
[353] Ibid.
[354] Ibid. [Italics original.]
[355] Ibid., 238-40 [184-6].

thus maintaining some distance between his argument and contemporary scientific theories.

Ancient atomism is a clarifying example of a virtual multiplicity to the extent that atoms both actualise variously and as a reciprocally determined multiplicity. If all beings are in fact composed of atoms, then their actualisation clearly has very great variability. Equally, there is no problem regarding resemblance, as atoms do not resemble actual beings. As a good example should, this gives us a clearer sense of the nature of the highly abstract conditions we have just discussed. Deleuze points out, however, that the atom "still retains too much independence, a shape and an actuality",[356] and thus reciprocal determination is limited in advance by substantial atomic form.

The example of ancient atomism, then, does not fulfil all of Deleuze's three conditions. As such, he proposes that "whether modern atomism, by contrast, fulfils all the conditions of a structure must be posed in relation to the differential equations which determine the laws of nature".[357] But whilst he returns later to differential equations, he does not discuss the relationship between contemporary atomism in physics and his own conception of a virtual multiplicity.

In his second example, "*the organism as a biological Idea"*, Deleuze proposes that Geoffroy Saint-Hilaire's biology may offer an example of a virtual multiplicity.[358] According to Deleuze, Saint-Hilaire did not attempt to supply conditions resembling a whole living being, or parts with pre-determined functions, but instead considered the parts which make-up organisms in abstraction of their form and function. Organisms are thus constituted from "purely anatomical and atomic elements, such as small bones", which do not have essential functions, but constitute functions through reciprocal determination upon actualisation.[359] Rather than thinking of the elements of living beings as necessarily fulfilling a particular function, instead their function results from actualisation and indeed reciprocal determination. Whilst elements may be fixed, their combination through actualisation is potentially infinite. Rather than attempting to grasp animals according to their actual shape or form, or parts according to functions

[356] Ibid., 239 [184].
[357] Ibid.
[358] Ibid.
[359] Ibid., 239 [184-5].

in-themselves, this method regards functions as resultant of multiple and reciprocal determinations relative to the whole.

Vital elements such as these are thus grasped in their virtual nature as "ideal connections beneath the cruder play of sensible and conceptual differences and resemblances".[360] In this sense, the virtual multiplicity of elements may actualise as a great variety of functions or animals, as opposed to a resemblant conception, whereby a potential-for-claw produces an actual claw, or potential-for-parrot an actual parrot. In fact, for Deleuze, this virtual multiplicity would be the condition for any and every organism: it is "an 'essence' which is the Animal in itself".[361] This essence does not anticipate the actual multiplicity of animals, then, but rather provides their multiple constituents and the source for their differential actualisation.

Deleuze concludes this reflection in a similar way to ancient atomism, with a doubt about this conception and a proposition that a more recent scientific theory may be an improvement. The problem is that "anatomical elements, principally bones" may not be sufficient for a "structuralism in biology", as this would elide other reciprocally determining elements like muscles.[362] Equally, similar to the example of atoms, Deleuze argues that bones themselves are too actualised in order to meet the requirements for elements of a virtual multiplicity. As such, he suggests that contemporary genetics may provide a more appropriate theory. Genes do not have actuality or form, but are elements which actualise variously, whilst "acting only in relation to other genes", they are also reciprocally determinant.[363]

But as for contemporary atomism, genetics comes as a something of a brief afterthought, and Deleuze does not fully pursue this example. Indeed, whilst genes would certainly be an apt and clarifying example of virtual multiplicities, to the extent that they do not have an actualised form, they are reciprocally determinant and must exist in conjunction with one another, and of course, they actualise variously. However, whilst genes may actualise in non-resemblant and various ways, this does not mean that their effects - as organs or beings, for example - are not specifically predictable. Indeed,

[360] Ibid., 239 [185].
[361] Ibid.
[362] Ibid.
[363] Ibid.

Deleuze does not reflect on the sense in which genes are used precisely to explain particular characteristics. Genes may produce differential repetitions, but these repetitions will be constrained by the capacity of that gene and its reciprocal capacity relative to others. In this sense, what Deleuze calls a "bare repetition" may in fact constrain the differential or "clothed repetition". It is our contention that this is precisely what the science of genetics attempts to grasp.

Deleuze's examples are certainly effective in terms of expressing his conception of a virtual multiplicity and their three conditions. But it ought to be noted that they fall short of fully identifying and affirming any contemporary natural scientific example. Indeed, part of the effectiveness of Deleuze's examples is that he identifies both the extent to which they are in keeping with his conditions and the ways in which they are not, which serves to reiterate and to clarify these conditions both positively and negatively. When it comes to natural science, however, there is a distinct vagueness in Deleuze's reflections. He merely suggests that more contemporary examples (modern atomism and genetics) might better fulfil his conditions, but he does not explore that possibility.

We have, of course, already expressed our criticism to some extent - that Deleuze fails to think the actual constraint on the virtual, which is crucial to scientific thinking. But we ought to pause for a moment to notice that it is rather strange that these contemporary examples are not pursued. It is odd that when Deleuze articulates the conceptual replacement for one of the key targets of his criticism, he only properly discusses examples which do not completely fulfil his conditions, offering more recent and apparently appropriate examples as unexamined afterthoughts.[364]

[364] Daniela Voss (2020) notes that Simondon and Deleuze differ as regards to their methodological use of examples, but underestimates the significance of examples in *Difference and Repetition*, proposing that Deleuze "objects to proceeding by means of paradigms. A transcendental philosophy in the sense that he intends to construct it cannot trace the transcendental from the empirical" (Voss, D., 2020, 103). As she recognises, this means affirming the metaphysical aspect of *Difference and Repetition* over and against the empirical (in his so-called "transcendental empiricism"). Voss does not recognise, however, that it also requires underestimating Deleuze's use of examples, and particularly the three examples used in the formulation of virtual multiplicities. In Voss' defence, one might emphasise the ambiguity and archaic nature of the examples Deleuze uses for virtual multiplicities, contending that they are merely devices for conceptual production. This, however, would mean that their historical and scientific plausibility is irrelevant, and that they are used merely instrumentally. This would then imply that the mathematical and scientific nature of Deleuze's other examples in *Difference and Repetition* is merely rhetorical, going

Our contention, in this regard, is that the structure of examples derived from the sciences is such that they constrain actualisation in advance, as we have argued regarding Simondon. In this way, Deleuze's critique of the resemblance of the possible and the potential is correct - the real conditions for crystallisation or for the genesis of a freshwater hydra, for example, are not potentialities or possibilities, nor do they resemble the beings which individuate. This ought to be regarded as an insightful development of Simondon's argument, which further pursues his criticism of the metaphysics of form and principles. But as we have argued regarding Simondon's examples, there is nonetheless a necessary connection which can be made between conditions, individuation and individuated or actual being, which in turn introduces a restraint on actualisation from the beginning. Whilst contemporary empirical science may articulate conditions which do not resemble what is produced (perhaps only an Aristotelian science would attempt the opposite), it also attempts to make necessary connections between conditions and their resultant beings or events.

There is tendency for vagueness when it comes to examples in *Difference and Repetition*, a propensity for broad descriptions without offering concrete examples of them. This is in direct contrast with Simondon's argument in *L'individuation,* which, as we have read it, works directly with theories and examples from the sciences in order to produce concepts and to further determine transduction. This contrast is clear in Deleuze's reading of Simondon's articulation of signal, form and information, for example, which we discussed in the previous chapter. Deleuze cites Simondon directly in this passage but modifies the terms, proposing that "Individuals are signal-sign systems".[365] A "signal" is defined as "two disparate orders capable of entering into communication" and a "sign" as their coming together: that which "flashes across this system, bringing about communication between disparate series, is a sign".[366]

Deleuze's reading of Simondon is accurate in its attention to the sense in which disparity requires compatibility, or things "capable of entering into communication". But we note that "form", the capacity for reception in Simondon's construction, drops out of the equation. Rather than a form which receives a signal, then, in Deleuze's gloss

against the trend in literature on Deleuze that maintains that *Difference and Repetition* is produced in light of contemporary scientific thinking.

[365] Deleuze, G. (1968 [1994]) 317 [246].

[366] Ibid., 286 [222].

"signal" is doubled or divided into two disparate orders which come together into a communication as a sign (which was "signification" or "meaning", for Simondon). To this extent, Deleuze's reading obscures the sense in which we might map compatibilities between beings and elements of a milieu. The omission of Simondon's "form" and its compatibility with a "signal" renders this description less determinate than its original, obscuring the sense in which, for example, an eye (a form) can be grasped as compatible with the "visible light" portion of the electromagnetic spectrum (a signal).

In this way, individuals appear as a communicational "flash" between disparate orders, whilst nothing is said of regularity. Indeed, some flashes may be more unique than others, or more different repetitions. This, it would seem, is precisely the practice of science and technics, that is, finding compatibilities and their regularity, mapping commonalities amongst differences. We do not have the space to go into Deleuze's long and complex discussion of intensity here, but we need note only that this discussion is demonstrative of the extent to which he distances the text from examples, and scientific examples in particular. Indeed, Simondon expresses form, signal and information as a reflection on the possibility for communication between a being and milieu, such that compatibilities and necessities, or the conditions for the transductive generation of beings, might be mapped. Deleuze offers no such examples and rather emphasises the indeterminacy of the description. That a sign "flashes" when two compatible series communicate tells us nothing about the regularity or repetition of these compatibilities. Rather, it is the broadest possible description of differential generation, and as such, a great distance from scientific thinking.

A scientific foundation for transduction

Thus far in this chapter, we have explored the sense in which Simondon's transductive philosophy comes after and rests on scientific thinking. Whilst transduction may be unlike induction or deduction, it depends nonetheless on scientific theories and concepts which themselves make significant use of deductive and inductive methods for thinking and confirmation. One of the results of the secondary and dependent position of philosophy relative to scientific thought, as it is articulated in Simondon's text, is that scientific concepts and theories limit the creative extent of preindividuality and individuation, or in Deleuze's case, differentiation and repetition. In this way, we have

argued that Simondon's proximity to scientific thought illuminates this constraint, both with regards to his own position and to that of *Difference and Repetition*. Thus, whilst repetitions may be differential, if they are informed by scientific thinking, they are nonetheless limited or constrained to an actuality or a "bare repetition".

We have thus been investigating the implications of the dependence of Simondon's transductive philosophy on scientific thinking, and the implications of this for *Difference and Repetition* (if we accept that scientific thinking makes possible the argument therein, that is). Up until this point, then, we have emphasised and discussed the constitution and constraint involved with scientific thinking: it constitutes or makes possible geneses and beings exemplified in Simondon's and Deleuze's texts, but it equally constrains their generation to specific descriptions. What we have yet to discuss is the sense in which scientific thinking *confirms* Simondon's text. Whilst we have discussed some of the ways in which scientific thought makes Simondon's argument possible, we have not explored what makes scientific thought itself possible, or what constitutes its claim to truth.

In this regard, we are in part attempting to respond to a broad tendency in the reception of Simondon's and Deleuze's texts, which celebrate their engagement with natural scientific thinking, whilst taking the veracity of scientific thinking as given.[367] There is a sense, for example, in which pre-twentieth century philosophy, and particularly Kant's Newtonianism is expressed as (to some degree at least) having been overturned along with the science that confirmed it.[368] In the same vein, philosophies appropriate to or dependent on twentieth century scientific positions are, more or less explicitly, confirmed and justified by a natural scientific bedrock upon which they rest. These comments should not be read as a damning critique, by any means; indeed, in the first two chapters to some extent we argued something similar to this. The historical irony, however, is hopefully clear: if a swathe of philosophical arguments and positions were invalidated with the decline or particularisation of Newtonian science,[369] then this begs the question as to the validity and security of the new scientific foundation.

[367] For example, Ansell-Pearson, K. (1999), De Beistegui, M. (2004), DeLanda, M. (2002).
[368] See, for example, Adorno, T. (2001), 3, 232; Caygill, H. (1995), 108; Prigogine and Stengers (1984).
[369] Bachelard, G. (2013), argues thus that Newton's science was not so much overcome, but incorporated as a part of Riemann's geometry.

Isabelle Stenger's discussion of Simondon is useful in this regard, because she both criticises his transductive proposition and affirms what she takes to be Deleuze's and Guattari's constructivism. This will serve to make the transition from our discussion of the scientific foundation for philosophy to the foundation on which science rests, ultimately leading us to a reflection on the precarity of scientific thinking. Stengers' text will also give us an opportunity to reflect on Deleuze's later position alongside Guattari, which, we contend, serves to almost entirely cut off communication between science and philosophy.[370]

Stengers criticises Simondon in the strongest terms for what she takes to be his attempt to rest his philosophy of transduction on the sciences. In this way, she argues that Simondon's philosophy of transduction, like any philosophy built on a scientific edifice, is bound to historical failure, and that transduction also fails the test of generality as some processes are not transductive. The most significant is the former, the argument that Simondon's philosophy of transduction rests a description of individuation on contemporary scientific thinking, which is a historically precarious truth. Thus, she contends that

> The history of philosophies of nature which have attempted to "rest themselves" [*s'appuyer*] on the sciences of their epoch recounts a series of failures, and Simondon's attempt seems to me inscribed in this history.[371]

This grasps something of the structure of Simondon's work that we have tried to express in this thesis, namely, that it depends on scientific theories and concepts. But it also points to perhaps the most significant and shared aspect of works of philosophy of science in the nineteenth and twentieth century, namely, that scientific truth is historical. (Stengers' contention that Simondon's venture is already written into a sequence of failures is perhaps a premature judgement, though, and one which we will return to later in this chapter.)

[370] It is worth noting at this juncture that our criticism of Stengers is specific to her texts dedicated to Simondon's work, and more specifically her contention that his texts lack a thinking of construction such as that of Deleuze's and Guattari's *What is Philosophy?*.
[371] Stengers, I. (2002), 307.

Stengers argues that philosophy should not depend upon the sciences, but instead grasp empirical science in the manner of a constructivism, like that which (she suggests) Deleuze and Guattari set out in *What is Philosophy?* Rather than resting philosophy on scientific resources, she argues that Deleuze and Guattari articulate a scientific constructivism based on the notion of the "function". In this way, Stengers plays Simondon's proposition that "relation has the value of being" back against him, to the extent that this relation might be an experimental relation between a theoretical function and a being which results from that (as a construction). Thus, she writes that a

> relation constructed between function and state of affairs which, in the experimental sciences, has the value of being, which brings into existence [*fait exister*] both the description and what is described simultaneously.[372]

This relation, of course, is of a different order from that which Simondon proposes. Indeed, whilst for Simondon a relation is something which a being enacts or even *is* relative to a milieu, what Stengers refers to above is a relation which would construct or produce a being according to the relation: function-state of affairs. Simondon's argument, which he describes as a "realism of relations", assumes that the ontological description of the relation is correct - that the eye of a living being receives energetic signals via electromagnetic radiation, for example - but does not make a claim about the relation which makes that description possible. On the contrary, Stengers is suggesting that empirical scientific descriptions are constructive relations between a concept and an empirical reality. She thus refers to the interpolation of a theoretical construction which would make possible the descriptions on which Simondon's work rests. There are thus two kinds of relation: first, transductive relation which Simondon claims is the ontological condition for all individuations; and second, the scientific or theoretical relation between concept and empirical data (a construction), which makes the former possible. This directs us to the problem that if the latter turn out to be improper or incorrect constructions, they could disprove the former.

This is at once a good reading of Simondon and a bad one of Deleuze and Guattari. Indeed, Stengers argues that Simondon fails to reflect on the "properly 'technical'

[372] Ibid.

character of the physico-technical notions that he intends to generalise".[373] This both clarifies the sense in which transduction relies on prior scientific work, and combined with her historical doubt, raises the question of the veracity of the scientific theories and examples on which Simondon's argument rests. Although Stengers does not quite express it in this way, the implicit problem is that if the empirical scientific constructions on which Simondon relies for transduction are erroneous, then so too will be Simondon's philosophy of transduction. We will turn to this problem in detail in the subsequent, and final section of this chapter.

First, however, we will reflect on the suggestion that *What is Philosophy?* offers a philosophical expression of the constructivist nature of science. Contrary to Stengers' reading, we contend that Deleuze and Guattari drive a wedge between science and philosophy to such a point that it appears that they have little or no relationship to one another. Indeed, Stengers' passage above refers to a construction as a relation between "function" and "state of affairs", but she fails to mention that this description is reserved purely for science and has no bearing on the work of philosophy. In this way, following Bergson's various terms for his major philosophical division (between time and duration, life and matter, quality and quantity, and so on), Deleuze and Guattari position scientific relations on the side of discursivity, actuality and quantitative multiplicity, and philosophy on the side of intuition, virtuality and qualitative multiplicity. In this regard, science works with "functions" and philosophy with "concepts", whilst they offer such a severe definition of the latter that it appears to leave philosophy and science unable to relate to one another.

Indeed, whilst Stengers refers to Deleuze's and Guattari's definition of the concept as if it pertained to a constructivism articulating natural scientific knowledge, in fact, their definition seems to entirely exclude science from the picture. Stengers twice invokes the following passage in order to demonstrate what she contends is Deleuze's and Guattari's constructivism:

> The concept is defined by its consistency, its endoconsistency and exoconsistency, but it has no *reference*; it is self-referential; it posits itself and its

[373] Stengers, I. (2002) 308.

> object at the same time as it is created. Constructivism unites the relative and the absolute.[374]

We have already said that the concept is reserved for philosophy, and the passage above provides further evidence for this. Indeed, a concept without reference, which is a positing of itself and its object has little bearing on a scientific constructivism which might be verified, rectified or falsified. Of course, any constructivism requires the sense in which a concept offers something positive or productive - constructing, rather than merely receiving. If a concept has no referent but itself, however, it is hard to understand how it might be disproved, which would seem necessary if the history of science, as Stengers claims, is a series of failures - or falsifications, errors and rectifications. How, we might wonder, can a concept fail if it only refers to itself, positing both itself and its object?

The paragraphs preceding this passage in *What is philosophy?* clarify this, and the meaning of the final phrase of the passage above: "Constructivism unites the relative and the absolute." Indeed, Deleuze and Guattari argue precisely that the concept is not relative to anything generally considered empirical - affection, sensible data, or information, for example. Rather, for them, a concept relates exclusively "to its own components, to other concepts to the plane on which it is defined, and to the problems it is supposed to resolve".[375] Equally, a concept does not find generality or regularity, or indeed correlations or patterns in nature - it is nothing like a category, then. Instead, for Deleuze and Guattari, the concept is absolute, it "speaks the event, not the essence or the thing - pure Event, a haecceity, an entity".[376] That is to say, a concept is the voicing of, or indeed *is* itself singular or individual. Whatever we might say about this definition of a concept or construction, it is hard to see how this could teach us anything about the work of science, which seems to be exactly their point. Philosophical concepts are a world apart from scientific functions.

When Deleuze and Guattari come to discuss science and philosophy (or "functives and concepts") together, the sense in which concepts are singular and "self-positing" is toned down, but any connection between the two remains very difficult to grasp,

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[374] Deleuze, G. and Guattari, F. (1991) 27 [22].
[375] Ibid., 26 [21].
[376] Ibid.

nonetheless. They argue that science "actualises the virtual" whilst philosophy gives consistency to the virtual, and that science has a discursive (as opposed to intuitive) method.[377] If we remember that a (philosophical) concept is singular, self-positing, immediate and without reference, then it seems that it could not depend on scientific thinking or functives. Rather, since concepts are singular and immediate, we might assume that science makes generalisations of the immediate and singular data of concepts. But they claim that this is not the case, rather, in order "to reflect and communicate" science requires only functives, and "Science does not need philosophy for these tasks".[378]

If the aims and activities of science are autonomous from philosophy, this does not mean that philosophy does not require science, however. Science may be able to actualise the virtual without the help of philosophy, but philosophy may need scientific guidance in giving consistency to the virtual. If so, it seems that we would arrive at the same problems we found earlier; namely, that the actualities of natural science would leave unbreakable constraints on the creativity of the virtual, whilst any scientific errors would be passed on to the secondary work of philosophy. And thus, Stengers' contradistinction between Simondon, on the one hand, and Deleuze and Guattari, on the other, would be unfounded.

In this respect, *What is Philosophy?* is rather unforthcoming, offering very little on the relationship that philosophy may have to science. The clearest proposition is that the two must relate across Bergson's distinctions between virtual and actual, duration and time, qualitative and quantitative multiplicities:

> It is true that this very opposition, between scientific and philosophical, discursive and intuitive, and extensional and intensive multiplicities, is also appropriate for

[377] Deleuze, G. and Guattari, F. (1991), 127 [133]. It is worth noting that the role of philosophy is not totally clear, even within the chapter in question. For example, they write both that "philosophy gives consistency to the virtual through concepts" [118] and that "philosophy expresses an event that gives consistency to the virtual on a plane of immanence and in an ordered form", 127 [133]; the first passage seems to argue that philosophy is an event which gives consistency to the virtual, the second that it expresses an event.
[378] Ibid., 111 [117].

> judging the correspondence between science and philosophy, their possible collaboration, and the inspiration of one by the other.[379]

But whilst they suggest that this division affords judgment of the correspondence and collaboration between science and philosophy, there is almost no discussion of what this actually amounts to. Invoking Bergson's terms serves to emphasise the distinction rather than any possible communication. Indeed, he does not express this division as a relationship of collaboration or inspiration, but rather of a distorted and emptied reality on the one hand, and a full and true image on the other. The point, for Bergson, is not to learn from or to be guided by understanding, time, or the closed systems of science, but rather to recognise their work and escape their effects. This division seems thus to merely state the terms of the problem, rather than its resolution.

Miguel de Beistegui's scientific reading of Deleuze sheds some light on this problem, with the proposition that philosophy produces a "*counter-effectuation*"[380] of the actualities grasped by the sciences. Unlike Stengers, de Beistegui does not claim the Deleuze affirms any kind of constructivism, and in this regard, he accepts the priority and the veracity of the sciences. Philosophy, in this way, makes a secondary movement to the virtual, guided by the scientific grasp on the actualisation of virtual multiplicities. Thus,

> from the actual, or the state of affairs, the concept returns upstream to the event, or the virtual…The scientific function, on the other hand, follows the path of the virtual in its actualization: it finds its references in the effectuation of the event in the state of things…the line taken by the philosophical concept in its movement upstream is not a segment of the line that the scientific function follows: they are two different lines, yet lines that meet or intersect in the actual.[381]

Concept and function thus pertain to philosophy and science respectively: the former moves towards the event or the virtual whilst the latter pursues actualisation. But we

[379] Equally, they write that "Concepts and functions thus appear as two types of multiplicities or varieties whose natures are different." Ibid., 121 [127] [italics original].
[380] Or a "counter-actualisation" in Peter Hallward's (2006) terminology. De Beistegui, M. (2004), 274.
[381] De Beistegui, M. (2004) 274.

might note that whilst Deleuze and Guattari propose that science "actualises the virtual", de Beistegui suggests a less active role for science which would merely "follow" the actualisation of the virtual. Equally, both *What is philosophy?* and de Beistegui's text reserve the virtual for philosophy, whilst in *Difference and Repetition*, as we saw, virtual multiplicities are precisely exemplified with contemporary scientific concepts (of atoms and genes). In the latter sense, science seems precisely to give expression to the virtual.

Whether or not the functions of science have a limiting effect on the virtual or philosophical concepts (for which it provides the guide) is not made clear either by Deleuze or de Beistegui. But, as we have argued, this is quite plain for Simondon. Indeed, Simondon's close engagement with examples and the sense in which the preindividual a marginal indeterminacy fully accepts that the conditions and individuating or actualising beings are constituted and constrained by those examples, (though they are not fully expressed by them, of course). In almost the opposite way, Bergson resists scientific concepts or actualities in order to retrieve the virtual. Indeed, even in *Creative Evolution,* which engages to some extent with biological thinking, he proposes that the true singularity of life is its continuous duration as the *élan vital*, but not the discontinuous systems of science. One wonders whether Deleuze cannot quite decide between these two options, or perhaps changes his mind from *Difference and Repetition* to *What is Philosophy?*. Indeed, the virtual in the former is not merely the remit of philosophy, as contemporary atomism and genetics give examples of virtual multiplicities, whilst in the latter, scientific practice appears cut-off from the virtual in Bergson's sense, by working to actualise it.

We must disagree, then, with Stengers' suggestion that Simondon's text could learn from a constructivism like that of Deleuze and Guattari, because their text makes a division such that science is separated from the entirely philosophical and absolute constructivism which they advance. The problematic relationship between the virtual and the actual is not resolved therein, and if anything, the division is further accentuated. Our discussion of Stengers' problem, however, has stressed the sense in which there is an option between either a virtual tethered to and limited by actual concepts which are supplied by the sciences, or a virtual which is a continuous whole broken up by the sciences. Simondon falls into the first camp: as we have argued throughout, transductive individuation is discontinuous and self-differentiating.

Equally, preindividuality is not a continuous and whole reality below conceptual or scientific divisions, but rather a marginal drive or energy. In this respect, Simondon's conception of analogy discovers the singular or individuating within scientific concepts (a singularity which is not aberrant for these concepts).

When it comes to *Difference and Repetition*, it is not clear on which side it falls. Sometimes the virtual therein appears to be a generalised and continuous singularising field, "clothed repetitions" below the discontinuous abstractions or "bare repetitions" of the sciences. But at other times it appears to be discontinuous, broken into Ideas or virtual multiplicities (supplied by the sciences) which could be linked necessarily with actualisations. In this regard, Simondon's text sharpens the Bergsonian options: *either* something like a continuous One-all given by sensation, *or* a discontinuous selection of concepts, given by rectified experience, or by empirical scientific thinking. What we have tried to emphasise with regards to Deleuze's texts, then, is that it is unclear as to whether he affirms the first or the second.

The task Simondon sets for thinking is not to de-actualise our own experience in order to recognise its durational continuity, or indeed to think life as a continuous whole below the divisions of science or the partial divisions which beings and species enact themselves. Rather, it is to think the universality of individuation as transduction, following the guidance of scientific thought. In this way, whether we call them actual or specific, scientific divisions leave an indelible mark on Simondon's thinking. But whilst transductive individuations are constrained and limited by these divisions, they are also made possible by them. Whether or not scientific thinking makes Deleuze's text possible, or indeed, whether his argument would be plausible without implicit justification from the differential and aleatory theories of contemporary science - such as those of thermodynamics, quantum mechanics and genetic evolution - we must leave to one side for the remainder of this thesis.

3. Conditions for scientific thinking

We disagree with the constructivism which Stengers proposes, then, but we ought to return now to her problem more broadly conceived, namely, that philosophies which rest on scientific theories are bound to historical failure due to theoretical rectification

or falsification. Rather than discussing the philosophical implications of particular scientific claims, this questions the possibility and the constitution of the scientific foundation on which Simondon's text rests. We may also phrase Stengers' criticism as a recognition that Simondon's argument can be made impossible, or indeed highly implausible, by the rectification or falsification of the scientific thought that makes it possible. The question is no longer the particular effects of this foundation - whether and how it may constrain creativity, for example - but rather its condition and its stability. In this respect, we can see that Stengers would affirm a constructivism precisely because it may be historically infallible. Indeed, a constructivism might aim to grasp what is ahistorical about scientific thinking, or the ahistorical conditions or structure of scientific history. If such a constructivism were successful, although theories and their co-constitutive objects may change, the philosophical grasp of their conditions or structure remains the same. In the following and final section, we turn to the nature and stability of this scientific foundation.

We will thus reflect on Stengers problem, rather than her suggested resolution. First, we discuss the broad implications of the un-verifiability of scientific thought, highlighting that the assertoric nature of scientific truth need not be cause for retreating from attempting an ontology informed by scientific thought. Second, we discuss the stakes of the more local movement in scientific thinking, stressing an irony in philosophies of becoming - like those of Bergson, Simondon and Deleuze - that cannot fold the generation of scientific thought into their ontologies.

The assertoric truth of empirical science

We have argued throughout this thesis that Simondon's philosophy of transduction rests on scientific thought, which in turn, works both to constitute and constrain the individuations that Simondon discusses. The difficulty for Simondon, or for any philosophy which depends upon scientific theories and concepts, is that the latter are subject to rectification and falsification. Scientific thinking confirms Simondon's argument in *L'individuation*, but by the same token, it can also disprove it. Much twentieth century philosophy of science bears witness to the actual overturning of theories and concepts. Equally, for example, Simondon's supervisor, Georges Canguilhem and an advisor, Gaston Bachelard, both had to re-learn aspects of the

sciences which studied due to theoretical upheavals in the twentieth century. However mathematical science may have become, the apodicticity of mathematics is not carried over to the empirical truths of the natural sciences.

Although it deals little in the actualities of science, Karl Popper's *Logic of Scientific Discovery* clearly expresses the assertoric nature of truth in the empirical sciences. Popper neatly encapsulates this in a citation from Albert Einstein: "In so far as the statements of mathematics speak about reality, they are not certain, and in so far as they are certain, they do not speak about reality."[382] This explains the sense in which apodictic certainty - where conclusions lead necessarily from premises - pertains only to analytic synthesis or rules internal to a system such as mathematics. Scientific research demands that thinking step outside of closed and necessary systems and into a reality subject to doubt and falsification. It cannot begin with an apodictic or doubtless foundation, and in this way, it may be read as an anti-Cartesian philosophy of science. Rather, when scientific thinking attempts to grasp the real or the actual, the best it can hope for is assertoric truth. In Popper's case, whilst a theory may be corroborated by numerous repetitions, it can never be absolutely or finally proven.

Empirical scientific theories, then, are fundamentally unverifiable and perpetually falsifiable, for Popper. In this way, he contends that induction proper is impossible, as it requires moving from a singular or particular empirical statement to a universal one, which in turn requires a prior "principle of induction". The problem is that any principle which could ground the veracity of induction cannot itself be inductive; rather, such a principle must be universal and non-empirical. If one tries to justify a principle of induction inductively, then that same induction requires its own principle, which leads to an infinite regress. The other option, Kant's attempt to "force his way out" of Hume's problem by deducing *a priori* synthetic concepts and principles is equally impossible. Indeed, rather than deducing them, Kant merely posits the *a priori* validity of the categories and principles, according to Popper.[383]

[382] Cited in Popper, K. (2002) Appendix i; footnote 4; 313.
[383] Popper does not deny causality, rather his move is to deny its inductive proof, in line with Hume, and *contra* Kant, to deny that it is an *a priori* condition of possibility. For Popper, however, causality is still hypothetically *a priori,* only it is not necessary or apodictic. Thus, a principle like Kant's is neither proven inductively nor cast out entirely; it is retained in the same form, only its modal status changes from

Instead, Popper argues, a scientific theory can only ever take the form of a hypothetical universal statement. A hypothesis is required in order to make the move from the singular to the universal (from *an* experience to the claim that something about this experience is universally repeatable), because any number of seemingly conceptually identical experiences do not prove that future repetitions will not falsify this claim. A hypothesis such as this is of a different order to empirical statements; it is not derived from the data of experience as true induction requires, but rather it makes a claim about possible or future experiences. Further, a universal hypothesis cannot be verified by any number of singular experiences because no amount of experiences can satisfy the demand for universality, as another future experience may falsify it.

Popper's claim regarding scientific thinking, then, is that it is always potentially falsifiable or unverifiable. This is not to claim that laws of nature may change from one day to the next, however. Rather, with reference to Hume's problem, if Quentin Meillasoux takes a radically ontological position - where nature's laws are themselves contingent[384] - then Popper's is like the epistemological mirror image, where the theories of natural law are contingent whilst nature itself is necessary. The potential contingency is universal hypothetical statements, which are the foundation of scientific knowledge, for Popper.

A singular experience can thus falsify but not verify a theory (this is the only sense in which science moves from the singular to the universal, or in an "inductive direction", for Popper). Indeed, even if a sufficient number of repetitions "corroborates" a theory and verification is snuck back in, truth is assertoric but not apodictic. Popper's text might get a little carried-away subduing a Cartesian anxiety about the apodictic, reformulating its absence in an unrealistically severe conception of scientific self-criticism. It is rather the infinite deferral of a final proof, or the assertoric nature of empirical theories which we are interested in when it comes to Simondon. Indeed, the problem for the articulation of transduction in *L'individuation* is that it rests on theories of assertoric truth, ones which are more or less "corroborated" or verified, but always open to rectification or falsification, without the timeless necessity of the apodictic. This

necessary to actual, and whilst it may be *used* for experience, it is ought to be subject to an interminable scientific technique of doubt.

[384] Meillasoux, Q. (2008).

precarity is further intensified the more theories Simondon refers, and then infinitely so in his hypothesis for the universality of transduction as the structure for individuation, that is, its truth for any and every individuation.

This may seem to affirm Stengers' proposition that philosophies resting on the sciences are bound to failure. Popper demonstrates that scientific theories are always potentially falsifiable, and thus we might take Stengers' advice and retreat from this unstable ground. But another way to read this would be to recognise that this is merely one of the demands of engagement with scientific thinking. Ontologies in dialogue with and made possible by the sciences surely risk failure, but so too does that scientific thinking on which they rest. If scientific thought is assertoric and falsifiable, then the ultimate danger for transduction (and for any other thought which rests on empirical scientific theories) is that theories or concepts upon which it relies are disproved. Stengers' criticism, however, founders when she attempts to give an example of this for Simondon's text.[385] Indeed, whilst she is derisory about Simondon's focus on Louis de Broglie's quantum theory and the absence of those of Heisenberg and Bohr, she does not explain the problems with de Broglie's theory, or how this might affect transduction.[386] Perhaps more significantly, Stengers does not reflect on the possibility for omitting theories or aspects from Simondon's work which are later found to be implausible. Indeed, whilst she notes that Simondon withdrew the section on de Broglie from the first and only publication of the thesis in his lifetime, she does not offer any explanation for this or reflect on its implications.

In this respect, Stengers' most significant criticism is that since the paradigm for transduction - crystallisation - is a process thermodynamically near-equilibrium, then this excludes any transductive description of far-from-equilibrium thermodynamic processes. She certainly knows better than most that crystallisation is accurately described by equilibrium thermodynamics, and she is also correct that Simondon's transductive description is, to a certain extent, based on the crystallising situation. But

[385] Stengers claims, for example, that Simondon's usage of crystalline metaphors - like the crystallisation of a thought, for example, make his work inarguable or unfalsifiable. But this is to attribute to Simondon a far more sophisticated rhetorical capacity than he is due, we contend, not to mention a vast over exaggeration of his usage of crystalline metaphor, which barely exists in *L'individuation* (tellingly, Stengers does not evidence this criticism). Stengers, I. (2002).
[386] David Bohm's recent return to de Broglie might serve to problematise Stengers' critique (and also Popper's claim that theories might be straightforwardly falsified).

her main criticism relies on a debateable reading which claims that Simondon attempts to define potential energy as if it were Aristotelian *dunamis* or Kantian possibility. Thus, she claims that energetic "potential" cannot apply to far-from equilibrium systems as it would entail a prediction of the future of that system. Simondon certainly attempts a definition of potential energy, and we also accept that his text would be improved had he recognised and thematise Stengers' criticism himself (which is much like Bergson's criticism of possibility). However, as we have argued, potential energy (as a prediction of future states) is not a crucial aspect of transduction, nor is it carried over to the other sections of *L'individuation.* To read Simondon's conception of potential energy as a claim that all transduction is predictable in advance requires omitting preindividuality from the equation.

Equally, whilst far-from-equilibrium thermodynamics may provide an extension or development of Simondon's argument, it is not clear that it is incompatible with it. Indeed, the focus of his discussion of crystallisation is precisely crystallis*ing*, whilst he criticises a focus on thermodynamic equilibrium or the crystallised state. Moreover, as we have argued, preindividuality works as a criticism of possibility or potentiality as attempts at absolute prediction. The preindividual precisely expresses the aleatory or the spontaneous which Prigogine and Stengers find in far-from-equilibrium systems.[387]

Stengers may be correct in presenting the history of science as a series of failures or indeed revolutions, but the difficulty is that if we cannot find an error on which Simondon bases his argument, then there is not yet any problem for his argument. Rather, like any scientific theory, according to Popper, those on which Simondon's argument rest are open to falsification, and more subtly (and *contra* Popper), rectification.

We have thus disagreed significantly with the content of Stengers' criticism. However, it demonstrates something significant about Simondon's work and any other philosophy which is made possible by scientific thinking, nonetheless. Indeed, it indicates the sense in which, for ontologies which rest on scientific thinking, the search for truth is shared with another discipline. Philosophy cannot, as it once was, be considered the highest in the order of the sciences, nor the final arbiter of truth. If we accept that

[387] See, for example, Prigogine and Stengers (1984), 131-46.

phenomenological consciousness alone cannot found ontology and that philosophy requires scientific resources, then ontology is necessarily bound to the precarious truths of the empirical sciences. In one sense, then, we can say that Simondon accepts this risk, but in another, if scientific thinking is necessary for contemporary ontology, then we might say that he merely meets the demands of ontology.

Approximation in scientific thinking

Gaston Bachelard offers a reflection on another kind of error in scientific thinking, presenting a more constructivist rejoinder more appropriate to Stengers' argument than that of Deleuze and Guattari. In his *Essai sur la Connaissance Approchée* Bachelard discusses the more quotidian role which error plays in approximation in scientific thinking. The essay raises two significant problems for Simondon's and Deleuze's propositions. First, whilst Bachelard accepts that the ultimate source or foundation for things may be moving and aleatory, he argues that this cannot be thought in itself or its singularity, but can only be approximated by scientific thought. Being is unknowable in its full richness and detail, since, whilst scientific thinking attempts to grasp it, there is always some inaccuracy. The task for science, in this regard, is to learn from its mistakes, recognising the aberrance of the detail before its hypotheses.

The second problem is the recognition that scientific thinking is itself moving, in a process of hypothesis, error and rectification. This, we contend, illuminates something of an irony or a blind spot in Simondon's and Deleuze's ontologies, to the extent that they present being as fundamentally becoming, individuating or differentiating, whilst scientific thinking is rendered a relatively static foundation. Bachelard does not contend that being is static, however, but that both being and thinking are processual.

Like Popper, Bachelard emphasises the hypothetical character of scientific truth, but quite unlike the former, he argues that the movement of scientific research is one of the rectifications of thought or concepts before the real. Thought, for Bachelard, is always in error, or to say the same thing, it illuminates a real which is always aberrant. Scientific approximation is thus perpetually moving, rectifying its reconstruction of a real which always partially escapes its grasp whilst orientating its improvement. Rectification is the operative word, it is "the fundamental principle which supports and directs

knowledge, and which ceaselessly pushes it to new conquests",[388] and describes the movement of thinking as a gradual enhancement of concepts in light of experimentation and new data from reality.

Popper's and Bachelard's texts are thus incommensurable to the extent that rectification is effectively Popper's cardinal sin, namely, the addition of *ad hoc* theses in order to save an erroneous theory in the face of falsification. Popper may have a point, to the extent that proponents of a theory may attempt to defend it even in light of disproof. (Thomas Kuhn presents a more pessimistic socio-psychological image, where a scientific revolution rarely breaks the faith of proponents of an older theory, who take it to their grave).[389] But Bachelard offers a more realistic sense of the improvement, or extension of theories - rather like what Kuhn formulates as "normal science".[390] Whilst Popper's falsificationism is ultimately all-or-nothing, prohibiting adjustment to hypotheses, Bachelard argues that gradual adjustment relative to the recognition of more minor errors is fundamental to the work of approximation in scientific thinking. Bachelard's text thus highlights the sense in which Popper's conception of hypothesis demands a complete theory which does not require improvement or rectification.

For Bachelard (as for Popper), thought comes first, enacted as a hypothesis about reality. What Bachelard stresses, in this sense, is that thought errs in the first instance, and its second task is to learn from the aberrance of the real relative to its initial hypothesis. The "act" of approximation, then, involves making a hypothesis and recognising its error or imprecision relative to the real. Thus,

> The imposition of categories is only the first time of knowledge, it is a classification which prepares the description. In order to describe the detail which escapes the category, one must judge the perturbations of the matter under the form.[391]

The category comes first as a form forced on matter, but the matter is aberrant and the concept erroneous. Error is realised as "the detail which escapes the category", which

[388] Bachelard, G. (2016), 16.
[389] Kuhn, T. (1996).
[390] Ibid., 23-34.
[391] Bachelard, G. (1928), 253.

demands and orientates a rectification of the initial hypothesis. The movement of thought is thus a discontinuous series of compromises or approximations made with the detail of the real. Form is thus not *a priori* synthetic - a condition for the possibility of reality unmixed with the empirical or the real - whilst matter's proper information is always aberrant relative to the hypothetical forms attempted by empirical science, which are never entirely accurate, or always err.[392] Matter, in this context, is not uninformed pure potential merely awaiting form. Rather, "the detail" is already informed, and scientific thinking must attempt to find a befitting form of thought. The task of scientific approximation, then, is to impose a hypothetical concept and to learn from the relative aberrance of the real, rectifying its forms relative to the perturbations of the detail.

Bachelard's conception of "the detail" is significant for our discussion because whilst, like Simondon and Deleuze, he maintains that being is fundamentally moving and aleatory - "chance reigns in the detail"[393] - he contends that it is properly unreachable in its singularity. Simondon's intuitive analogy, which reflects the individuality of an individuation as a reflection in thinking, or Deleuze's and Guattari's proposition for singular concepts which give consistency to the virtual, are thus impossible for Bachelard. Rather, he argues that the aleatory and becoming nature of real is only known through the recognition of that which escapes the concept.

This is the work of approximation, which grasps a generality but acknowledges that it always misses something of the detail. In keeping with what we have said regarding the requirement of scientific thinking for (post-phenomenological) ontology, scientific approximation is the only way to reach certain beings or aspects thereof. Some individuations, at least, cannot be reached either by pre-scientific affection or consciousness, nor, *qua* individuation, by science.

One of the problems with the detail, according to Bachelard, is that it does not fit the criteria of "our" scale. When we descend to the microscopic, the real loses coherence, and in certain situations, we have no hope of going further than an approximation. At "our" scale there is relative stability, or the real is "slower than thought", "before the

[392] Ibid., 266.
[393] Ibid., 288; 246.

detail, in the infinite complexity united with the extreme mobility of the infinitely small", coherence is lost.[394] At the scale of the detail or singularity, the real "returns to a multiplicity somehow anterior to all creation, refractory of all construction".[395] Simondon or Deleuze might variously suggest that at this very moment, when we reach a multiplicity which resists conceptual construction, philosophy ought to step in. Indeed, for Simondon this might signal the domain of preindividuality or even analogy, where thinking immediately reflects an individuation, or for Deleuze the expression of clothed (as opposed to bare) repetition. Bachelard's point, however, is that at this scale, reality cannot be intuited or thought immediately in its singularity, that is, without generalisation or approximation.

The problem is not so much that there is no science of the singular, but that there is no access at all to the singular. Indeed, the problematic of Simondon's analogy is the same, namely, that the detail describes events or individuations unintuitable or insensible, beings which are singular but so too separate from us. Bachelard's resolution is quite different, however, as he maintains that we cannot think such individuations in-themselves. The chance movement of reality can be detected as such by scientific thinking, but it cannot be thought in its full difference or singularity. For certain phenomena and at certain orders of magnitude, reality can only be grasped according to generality - approximately or probabilistically - whilst its singularity recedes into darkness. In this way, he writes that

> We will never be able to create images apt to represent the prolixity of a becoming and of a being which has firmly broken with our level. Thus, as we have seen, the agitation of molecules of a gas cannot be described in an entirely objective manner, in its detail; it can only be known from the outside, by averages, by effects of the whole which return to the level of our real. Similarly, having no means for gripping its minimum becoming [*resserrer son devenir minimum*], thought can no longer measure the vertiginous and multiple becoming of atoms.[396]

[394] Bachelard, G. (2016), 257.
[395] Ibid.
[396] Ibid.

Brownian motion (or "the agitation of molecules") or the becoming of atoms are thus processes which resist absolute prediction, and most certainly immediacy as analogy or affection. The movement of molecules is predictable and necessary at the macro scale, or approximately, whilst at the micro scale this movement is unpredictable. In this regard, pre-scientific consciousness does not find singularity where science generalises, instead, scientific thinking is required in order to have any access at all to Brownian motion.

This casts very serious doubt on Simondon's analogical thinking. Indeed, we cannot reflect the individuation of a crystal or a living being in the same sense that we cannot reflect or know the singularity of the chance movement of molecules. But this does not signal a return to pre-scientific or phenomenological consciousness, whose access is equally barred from these events.

Bachelard's presentation of conceptual approximation is rather like Deleuze's notion of a bare repetition, a concept of resemblance from which difference has been stripped out. However, in this sense, whilst we may know that a clothed or differential repetition exists, we may not be able to think or intuit it in its singularity. If science comes first and delineates the approximate or statistical actual and philosophy "returns upstream, ascends the very slope down which science descends"[397] to reach the virtual, philosophy may never reach more than a blank or empty description of difference in-itself, or preindividual energy. Bachelard argues thus, that

> On the plain of the detail, Thought and Reality appear detached, and one can say that in distancing itself from the order of magnitude at which we think, Reality, in some sense, loses its solidity, its consistence, its substance. In summary, Reality and Thought sink together into the same nothingness, into the same metaphysical Erebus, son of Chaos and of the Night.[398]

[397] De Beistegui, M. (2004), 14. In this way, de Beistegui counterposes eidetic reduction and transduction: "from "reduction" to what Simondon, and Deleuze after him, calls "transduction," that is, from the movement of phenomenological thought, which reduces the difference of the empirical world to the identity of a transcendental consciousness, and the difference of singularities to the identity of essence, to transcendental empiricism, in and through which the differential play behind identities is revealed." Ibid., 286.
[398] Bachelard, G. (2016), 257.

Remembering that this essay (like much of Bachelard's work) is in dialogue with Bergson's work, and particular his *Essai sur les donnés immédiates de la conscience*, the passage above might be read as a description of the limits of the personal intuition of duration. Whilst an immediate intuition of one's own duration may be possible, those which are neither ours nor at "the order of magnitude at which we think", are not. If thought and reality merge in the detail, they also slide into darkness. As we have argued, however, this darkness is not "nothingness" as Bachelard puts it here. Rather, it is generative and creative, only as such or in-itself it escapes thought.

Finally, the other aspect of Bachelard's text which is significant for our discussion is that it presents both being and thinking as moving. Whilst Simondon and Deleuze both affirm the becoming of being, they make use of a static conception of scientific thinking. The problem is not that they do not recognise that scientific thought changes and develops - Simondon clearly acknowledges this in his discussion of induction and deduction, for example. Rather, if they are at pains to articulate the movement of being, their presentation of scientific thought is an invariable foundation. Simondon's examples or Deleuze's "structural" virtual multiplicities and actual beings do not change. Indeed, whilst Bachelard presents scientific theories and concepts as mere "resting places" in the movement of scientific thinking, the scientific condition for Simondon's transduction is unchanging.[399] In this sense, Bachelard's text offers a constructivism more appropriate to Stengers' query, one which recognises the movement of scientific thinking, and the instability of its concepts and theories.

One might respond with the contention that Simondon highlights the fact that further scientific work is required, which he claims will expand our understanding of various aspects of individuation. He proposes, for example, that further research on limit cases between the physico-chemical and the living like the tobacco filtering virus, or further work on the effects of the polarisation of matter are required for the project in *L'individuation*.[400] The problem is that he does not acknowledge that those theories on which his argument rests may be subject to rectification or falsification. Bachelard's text is helpful alongside Popper's or Kuhn's, for example, because it emphasises the more gradual movement of scientific thinking (without the absolute destruction of

[399] Bachelard, G. (2016) 256.
[400] Simondon, G. (2013) 153, 227-8; 201-2.

falsification or revolution). This illuminates the moving foundation of Simondon's argument in *L'individuation,* which is somewhat obscured by the movement of its individuating expressions.

We have disagreed considerably with Stengers' argument, but we may concur that the precarity and temporariness of scientific thinking must be taken into account, especially if it is also held that scientific thinking inspires, orientates or indeed grounds ontology today. If we read Simondon's and Deleuze's texts as in part syntheses of the work of Bergson, on the one hand, and Bachelard and Canguilhem, on the other, we might thus contend that they underestimate the epistemological and historical lessons to be learned from the latter. Whilst both Simondon and Deleuze invoke scientific thinking, they do not reflect adequately on the nature of its conditions, and as we have argued, make use of scientific concepts and theories *as if* they were completed or indeed, individuated. Bachelard's rejoinder, in this sense, would be that thought is always in error, which is why it is an always unfinished construction of the real. Ironically, the scientific thinking that makes possible examples such as crystallisations, atoms, genes and biological reproduction is moving like the individuations of Simondon's and Deleuze's texts, only in a different sense.

Conclusion

It may seem, finally, that we agree with Stengers, and that we ought to leave Simondon behind entirely. This has not been what we have attempted to demonstrate, however. We have doubted the possibility for an analogical thinking, requiring a contradiction in terms in an immediate reflection of an individuation. Equally, we have doubted attempts to think the virtuality or singularity within scientific examples or actualities. But this does not mean that Simondon and Deleuze have nothing to teach us about the being of the sciences. Indeed, if our reading of Bachelard's reflection on approximation, error and rectification relative to detail cast doubt on the thinking individuations, it equally affirmed the aleatory nature of being. Similarly, if we agreed with Stengers that philosophies founded on the empirical sciences ought to recognise, at least, the movement of their foundation, this does not mean that Simondon and Deleuze have nothing to offer, regarding ontology.

Rather, throughout this thesis we have attempted to demonstrate the sense in which contemporary ontology requires scientific thinking, in its partial departure from the priority of a transcendental consciousness. In this way, Simondon and Deleuze make significant contributions with concepts such as transduction and virtual multiplicities, which both reformulate ancient philosophical notions - individuation and essence - according to contemporary scientific thinking. Whilst neither are entirely successful, they nonetheless offer significant contributions to the task of ontology today. That said, it must be noted that both Simondon and Deleuze, to a certain extent at least, take scientific thinking for granted. They fail to fully reflect on the sense in which scientific theories and concepts serve both to make their ontologies possible, but also restrict the creative capacity of being. Finally, both underestimate the sense in which scientific thought may also render their arguments impossible, or partially so, the sense in which both being and science are becoming.

Conclusion

Simondon's transductive philosophy makes a significant contribution to contemporary ontology, in its powerful claim for the fundamentally energetic nature of beings. Transduction sheds light on both the generality of generation and the sense in which many (if not all) beings are becoming, and more specifically, the sense in which these becoming beings can only exist as conversions of energy. This shifts the focus of ontology from the primacy of perception to generation, whilst potentially incorporating different forms of perception as sensory transductions. Indeed, as we have discussed, beings convert energy in order to continue to be, but they also convert energy in order to experience a world and to orientate themselves within it. The electromagnetic spectrum describes the milieu relative to which plants maintain their being through photosynthetic conversion, for example, but it also expresses the nature and laws of a milieu relative to which beings endowed with the ability for photo-visual transduction are able to "see". If a universal concept for ontogenesis is possible today, it is difficult to think of a better candidate than transduction, considered as the conversion of energy.

We have also attempted to emphasise the contribution that Simondon makes with his conception of transductive relation. Kant's transcendental philosophy, and that of its ecological heirs in philosophy, physiology and biology, produced a substantial conception of relation - to the extent that objects or beings are a function of a relation, rather than substances indifferent to their relation to thought. But Simondon's innovation is to produce a conception of a relation which is generative of beings themselves, not only of their worlds or the phenomena therein. Rather than thinking beings as a function of transcendental synthesis, as in Kant's philosophy, or perception, as in the work of von Uexküll or Heidegger, Simondon shifts the question and asks instead after the individuation or creation of beings. His engagement with energetics thus offers a conception of ontogenetic relation which enables us to think the conversion and use of energy as a fundamental condition for the genesis and maintenance of beings; signalling, perhaps, the fundamentally energetic nature of the being of beings.

Further work remains to be done with regards to thinking the relationship between the scientific and philosophical understandings of energy, and the possible elision of energetics and ontology more generally. The historical significance of the development of concepts of energy, both for philosophy and science, remains regrettably understudied. Indeed, the transition from nineteenth-century physics and physiology to the physics and biology of the twentieth and twenty-first centuries are of profound ontological and historical importance. This period saw a shift from a physics dominated by principles of mechanism and concepts of force and matter, to one for which indeterminacy, relativistic time, and the concepts of energy and quanta are core elements of almost all branches of science. Modern European philosophy, however, has been slow to recognise this. Simondon's work, along with that of Bergson, Deleuze and their readers have made important contributions to thinking through the nature and implications of this historical shift, however, we contend that much remains to be understood regarding the nature of energy and its significance for matter and life.

We should also note that our focus on Simondon's work has necessarily come at the expense of closer engagement with other thinkers. In this regard, more focussed and lengthy critical discussion of energy in Heidegger's work is required. Indeed, Heidegger seems to forget energy in his reflections on human and animal life (and so too, perhaps, in his anachronistic overvaluation of force when reading Aristotle's *Metaphysics Book Theta*), whilst later energy becomes utterly central for his critiques of technics and cybernetics. Similarly, the role of thermodynamics and energetics in the work of thinkers such as Bergson, Deleuze and Stengers - all of whom criticise the first law of thermodynamics, but affirm the second, for example - has remained marginal in this thesis, but ought to be brought into clearer view in future.

Hopefully, then, we have clarified and emphasised both the energetics and relationality of Simondon's conception of transduction. But so too, we hope to have articulated the openness of Simondon's position in *L'individuation*. Hypothesis and experiment are the modes of writing most common in the mid-sections of that text, which discusses examples in fine detail in order to open up problems and puzzles, emphasising at once the general capacity of transduction, but also its limits. Whilst the Introduction can appear like a series of thetic statements to be defended later in the work, instead, the rest of the text reads as thinking, relishing in the extraordinary and the irresolvable as

much as in resolutions or conclusions. Living beings may not be reducible to transductive unity, a crab and a sacullina may be almost one whilst protozoa may be less than one, and understanding of the limits between physical and living individuations may await further research (like that of the tobacco mosaic virus, which seems to sit at the limit between the physical and the vital).

We have attempted to give a coherent expression of much of Simondon's argumentative work in *L'individuation*, but some of the detail will have necessarily escaped our grasp. In this regard, we hope that future work on Simondon might attempt to carefully read the puzzling and knotty thinking in the mid-sections of *L'individuation* in light of, in spite of and in contrast to the declarations of its introduction. We have also highlighted moments where Simondon's thinking falters, or where more honest sections of argumentation disagree with the rhetoric of his text; we hope that Simondon's work will receive more of the close and critical engagement that it deserves in the future.

If the major contribution of Simondon's philosophy of transduction pertains to its thinking of the relational and energetic genesis and nature of beings, a major weakness lies in its underestimation of the conditions for the possibility for that position. Simondon brings energy and information to a philosophical tradition which has vastly underestimated their significance, but so too, he underestimates the significance of the scientific thinking which makes his contribution possible. We thus argued that scientific concepts and theories make Simondon's transductive philosophy possible, but so too they constrain the creativity of being. In this regard, neither Simondon nor his readers hitherto fully recognise the implications of the scientific foundation for his argument. As we maintained, however, this problem is not unique to Simondon, and Deleuze's early work shares a similar weakness. Whilst scientific thinking makes many of Simondon's and Deleuze's most interesting contributions possible, so too it serves to limit generation and creativity in ways that they do not fully acknowledge.

Finally, Simondon's argument does not fully acknowledge the sense in which the scientific thought on which it depends is itself moving; not so much thought, but *thinking*. Our discussion of this problem has been necessarily limited, and further research is certainly required, in particular reflection on the divergences between French thinkers of historical epistemology and those of genetic ontology in the

twentieth century. Simondon and Deleuze both arise from a milieu steeped in the tradition of historical epistemology of science and move towards the thinking of ontogenesis, but in so doing they may have forgotten significant lessons in the history of science. Ultimately, then, we maintain that there is an irony at the heart of Simondon's philosophy, to the extent that it would at once return to the pre-Socratics for an operational or moving image of nature, combining this with contemporary scientific theories and concepts which support this genetic picture, whilst remaining almost entirely mute on the operation or the movement of science. Transduction, as we have argued, is founded on scientific thought, but this may be a collection of mere resting places, temporary footholds in a double movement of thinking and being.

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