

## Introduction

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Do we need the notions of causal power and disposition to account for change? If there are powers, are they causes? Or do we rather have reason to deny such powers any ontological reality? Although questions of this sort occupy centre stage in a considerable part of contemporary work on powers and dispositions<sup>1</sup>, they are not new. However, received opinion has it that modern philosophy and the new science of mechanics of the 17<sup>th</sup> century were constituted in opposition to those all too famous ‘virtues’ – a term used during that epoch to designate powers – upon which the scholastic doctors – the medieval philosophers and their 17<sup>th</sup> century heirs – were reputed to ground all causal explanations. Suddenly, or so tradition has it, it became evident how ridiculous it was to explain, as Molière’s<sup>2</sup> bachelor candidate, that opium makes one sleepy because opium possesses a ‘dormitive virtue’ (*virtus dormitiva*), in other words, a power to make people sleep. The final blow against the notion of power would have been struck by Hume whose analysis of causation eliminates all recourse to the notion of power in the explanation of change. Since then, causation has been considered as a certain type of relation between two actual events that must satisfy a certain number of conditions (temporal succession, contiguity, repetition).<sup>3</sup>

The aim of this introduction is to improve on the traditional way of summing up the history of the notions of power and disposition, by uncovering some of the complexities that remain hidden behind such an oversimplification. We shall proceed in two steps. First, we shall have a look at the way in which the notion of power, handed over from the Aristotelian and scholastic tradition, was interpreted by some of the most representative authors of the modern epoch, in the 17<sup>th</sup> century. Second, we shall examine why, once the notion of a law of nature had become available, many philosophers, from that epoch to the present, judged the notion of disposition superfluous, and why that notion has nevertheless returned to occupy centre stage in the work of many contemporary thinkers.

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<sup>1</sup> In this introduction, we shall use the expressions ‘power’, ‘disposition’ and ‘capacity’ interchangeably.

<sup>2</sup> the famous scene in Molière’s *Le malade imaginaire*, troisième intermède, in G. Couton (ed.), Molière, *Œuvres complètes* (Paris, 1971), p. 1173; trans. A.R. Waller (Edinburgh, 1926), vol. 8, p. 308.

<sup>3</sup> We shall come back to Hume later in this introduction.

### Powers and Dispositions in Early Modern Philosophy

It goes without saying that we do not pretend to provide, in these pages, the complete history of philosophical thought about powers and dispositions. However, it is quite safe to say that the 17<sup>th</sup> century constitutes a turning point in that history. Descartes, in particular, plays a crucial role. Indeed, arguing against a scholastic tradition that grounded the explanation of change on the action of ‘substantial forms’ or ‘real accidents’ (the precise nature of which we shall return to later), Descartes replaces this kind of explanation with a conception according to which matter has an essentially spatial nature. The wealth of qualities and changes of matter, as well as the different phenomena of generation and corruption, could and must and can be explained by the mere configuration and movement of the parts of material objects.

Thus, weight and heat, which give bodies the power of falling and fire the power of burning them, must not be explained by the presence in the rock of a real accident that ‘pushes’ the body to fall, or by a substantial form of fire that explains the body’s containing heat as well as its capacity to burn other bodies. Weight and heat should rather be conceived of as purely mechanical effects of different parts of extended matter that the new science of matter would explain.

Before returning to this opposition, crucial for our purposes, between the scholastic doctrine and Cartesian philosophy, we should pause to note that Molière’s candidate’s answer is not so empty as it appears. We can see why, by formulating more charitably the question he might have faced: that is, not *why opium makes people sleep*, but rather *why people fall asleep after having absorbed opium*. In replying to the latter question, it is not trivial to answer that opium has the power to make people sleep, in other words that it is a soporific. Criticism of the answer, thus understood, raises substantial issues rather than boiling down to a mere accusation of ‘tautology’. On this basis, we can distinguish three types of criticisms that this reasoning elicits in the seventeenth century.<sup>4</sup>

First, the explanation relying on dormitive virtue can be criticized on *empirical* grounds: it is simply wrong that opium has such a capacity, just as inquiry has shown it to be wrong that garlic has any anti-magnetic power. The very idea of a power inhering in things is not absurd; it is just that experience shows that certain attributions of faculties to certain substances turn out to be unfounded.

Second, without eliminating the dormitive power of opium, it may be argued that it reduces to another type of power. This *reductionist* reply aims at reducing the number of powers. Maybe opium has only a *virtus fatigativa*, a power to bring about weariness that it shares with bad novels, and it is a person’s weariness that eventually induces sleep. The complaint that explanation by powers tends to arbitrarily multiply the number of virtues and thereby makes them lose their

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<sup>4</sup> We draw here on the excellent analysis in K. Hutchison, ‘Dormitive Virtues, Scholastic Qualities, and the New Philosophies’, *History of Science*, 29, n° 85 (1991): 245-250.

explanatory strength because a new specific power is hastily introduced for each new effect to be explained, was often voiced in the seventeenth century. Nevertheless, it does not by itself discredit the notion of power as such. Newton occasionally accuses those who postulate specific powers behind each effect, not to explain anything at all.<sup>5</sup> However, all he wants to say in this context is that it is not sufficient, in order to explain the elliptic form of planetary orbits, to attribute a *virtus elliptofactanda*<sup>6</sup> to the sun, bypassing in this way authentic scientific work. Newton's criticism does not exclude the hypothesis that the sun has a gravitational power whose mode of operation it took Newton's genius to reveal. A good scientific explanation must end up reducing of the number of powers that must be postulated, but not necessarily eliminate the concept of power itself.

Finally, it is possible to deny the very existence of powers in *natural* beings, for a very particular reason: between ingesting opium and falling asleep one observes the existence of a relation of succession; nothing forces us to postulate anything like a real causal relation and hence an active power in opium to ground that relation. In fact, it is not logically absurd to suppose that an external agent arranges things in such a way that, *on the occasion* of a person ingesting opium, the person falls asleep. The only power at work in this bringing about the person's falling asleep belongs to the external agent. Once again, the coherence of the concept of cause itself is not at issue. It is only its extension that is reduced to a minimum, because the capacity to act is attributed to one single being alone. Malebranche's writings illustrate well this 'occasionalist' position, according to which all apparent operation in nature must be attributed to a supernatural agent, God. In other words, all causal relations are grounded in a 'general order of nature' governed by divine operation, rather than by the particular faculties inherent in natural substances, the latter being deprived of any capacity of affecting other substances.<sup>7</sup> As we shall see, it suffices to abstract from the divine hypothesis to open the path for Hume's new analysis of causation.

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<sup>5</sup> For Newton, 'to tell us that every Species of Things is endowed with an occult specifick Quality by which it tacts and produces [...] effects, is to tell us nothing'. Newton, E.T. Whittaker (ed.), *Opticks, or Treatise of the Reflections, Refractions, Inflections and Colours of Light* (New York, 1931), p. 401; quoted in K. Hutchison 'Dormitive Virtues, Scholastic Qualities, and the New Philosophies', p. 250.

<sup>6</sup> See K. Hutchison 'Dormitive Virtues, Scholastic Qualities, and the New Philosophies', p. 251.

<sup>7</sup> See, e.g., Malebranche: 'I hold, as I have said elsewhere, that bodies, for example, do not have the force to move themselves and that therefore their *motor force* is but the action of God'. N. Malebranche, 'Eclaircissements sur la recherche de vérité' in Rodis-Lewis (ed.), *Œuvres* (Paris, 1979), vol. I, p. 1003; trans. T.M. Lennon and P.J. Olscamp, 'Elucidations of The Search After Truth', in *The Search After Truth, Elucidations of The Search After Truth* (Columbus, 1980), p. 678.

*Change and Power in Aristotle*

In the seventeenth century, it is common to attribute the abhorred doctrine to the ‘School’ or to the ‘peripateticians’, in other words to the medieval heirs of Aristotle and hence to Aristotle himself. However, Aristotle’s own writings do not contain any trace of the notions of real accident and substantial form as entities distinct from the substance of which they are supposed to be the accident or the form. Let us briefly recall Aristotle’s theory of change.

Where there is change, there are causes of change. Aristotle distinguishes four types of causes (or types of explanations, the Greek term *aitia* allows for both readings)<sup>8</sup>: *that of which a thing is made*, or material cause (the clay is the cause of the statue in this sense, as are the letters of a syllable), *the form of the thing* or *the definition providing the essence of the thing* (this piece of bronze is a statue, this flowing water is a river), *that which produces the thing* or the ‘agent that produces the effect, changing it from what it was to what it is to be’<sup>9</sup> (the father is the cause of the child in this sense, as is the architect of the house) and the *end* or *purpose* (health is the reason, or cause, of the walk). There are three important things to note about this classification.

First, Aristotle’s causes are by definition that *what is given by the explanation* of what happens, of what persists and in general of what must be accounted for. Thus, the definition or form of a thing is a cause because it ‘accounts for’ what the thing is by giving its essence. Hence, causes are not in the first place, nor essentially, events (or descriptions of events), as they are in modern theories of causation. In Hume’s theory in particular, goals, agents, form and matter could not be taken to be causes because they are not events or ‘happenings’.

Second, the formal cause or simply ‘form’ of a thing constitutes what Aristotle calls its *nature*. Aristotle’s physics is structured around the concept of beings that ‘have within themselves a principle of movement (or change) and rest’<sup>10</sup>, contrasted with artificial objects, such as a bed or a tripod. In particular, each of the four elementary substances, water, fire, air and earth, behaves differently in circumstances of a given type (for example of temperature). These ‘simple bodies’<sup>11</sup>, as Aristotle calls them, behave in a specific manner according to their nature, in the sense that their nature determines the types of changes these simple bodies may undergo. Thus, the nature or form of a thing *accounts for* the type of change it undergoes, and can therefore be counted among its causes.

This brings us to our third point. For Aristotle, no change can come about without an agent (the moving or, in the literal use of the term, efficient cause) and his

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<sup>8</sup> Aristotle, trans. P.H. Wicksteed and F.M. Cornford, *Physics* (Cambridge, 1929 and 1934), book II, ch. 3, 194b24-195a3 and ch. 7, 198a14-21.

<sup>9</sup> Aristotle, *Physics*, book II, ch. 3, 194b31.

<sup>10</sup> Aristotle, *Physics*, book II, ch. 1, 192b14.

<sup>11</sup> Aristotle, *Physics*, book II, ch. 1, 192b10 and Aristotle, trans. E.S. Forster, *On Coming-to-be and Passing-away* (Cambridge, 1955), book II, ch. 3, 330b30.

conception of an agent is essentially that of a substance operating on another substance, the latter *suffering* the process of change. This is why it is named 'patient'.<sup>12</sup> Even the behaviour of living beings must be conceived of according to this model, even if in their case, unlike the case of nonliving natural substances, agent and patient are identical. The acting agent who affects the patient therefore has the *capacity* or the *power* to act; and the patient has the capacity or power to undergo the agent's action. From this it follows, at least in principle, that one would commit a category mistake (in the modern sense of the expression) if one confused the formal and the efficient cause. In the strict sense, the form does not act.<sup>13</sup> Opium certainly possesses a form that accounts for the type of action that it can perform on certain patients. However, this does not at all imply that the form is an internal entity that pushes the opium to have its cataleptic effects. It is the opium, not its form that operates to bring about the patient's falling asleep, where the form merely determines the types of action that its bearer is capable of performing and thereby the types of capacities it possesses.

This conception of change leads Aristotle to distinguish between potentiality or power (*dunamis*) and effectivity (*energia*), which is the realization of the power.<sup>14</sup> Any entity that is potentially something realizes this potentiality by being the subject of a process, taking it from a state in which it is not that something to a state in which it is effectively that something. In this sense, the acorn is potentially the oak tree, and the oak tree is the realization of that power. That process of change (*métabolé*) can take four forms: substantial (coming into being, ceasing to be, for substances in general; birth and death, for organisms in particular), quantitative (growth, shrinking), qualitative (gain or loss of this or that quality, for example becoming white) and local (change of place, locomotion).<sup>15</sup> A change in this sense is a *process* (by opposition to a simple activity, such as seeing or walking) characterised by the fact that 1) it manifests a progression from an initial state to a final state, from a state where that which undergoes the transformation, the patient, has something potentially to a state where the same patient has this something effectively, 2) it takes time, which makes it possible to say that it is quick or slow and 3) it is constituted by differentiated steps (when one builds a house, one starts with the foundations, then builds the walls and ends with the roof).<sup>16</sup>

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<sup>12</sup> Aristotle says that the change is in the patient; see *Physics*, book III, ch. 3, 202a15.

<sup>13</sup> On this difficult problem, see A. Mansion, *Introduction à la physique aristotélicienne* (Louvain-la-Neuve, 1987), ch. 7.

<sup>14</sup> Aristotle offers an analysis of the notion of power in Aristotle, trans. H. Tredennick, *The Metaphysics* (Cambridge, 1933), book IX (θ).

<sup>15</sup> See Aristotle, *Physics*, book II, ch.1, 192b15, *On Coming-to-be and Passing-away*, book I, 319b32-320a2.

<sup>16</sup> See Aristotle, *The Metaphysics*, book IX.

Aristotle sums up this doctrine in his famous definition of change as ‘the progress of the realizing of a potentiality, *qua* potentiality’.<sup>17</sup> This definition has been accused of being circular, because it defines change by characterising it as a *process* going from the power to the realized power. However, effectivity does not mean ‘movement of realization’ or actualization, but rather actuality or reality. Aristotle simply intends to categorize movement among the effective realities, and not as something ‘under way’ between a power and its realization. Indeed, the pieces of wood before me have two kinds of power: to be a table and to get transformed into a table (to be changed into a table). The table that exists is the effectivity of the first power, whereas the change affecting the pieces (the action of constructing the table) is the effectivity of the second power. My action of constructing the table is the effectivity of the power inherent in the pieces of wood, the effectivity of the constructible as constructible (Aristotle says, of the constructible ‘as such’), a power the pieces possess in virtue of being capable of undergoing that change, and not, e.g., by virtue of being owned by the agent.

The distinction between power and effectivity can be drawn both with respect to a substance and with respect to an accident (for example a quality). The wine in this bottle *can* acquire new aromas by ageing: if this power gets realized, the substance, i.e. the wine, persists but acquires new qualities. The change is accidental. However, the same wine *can* also get transformed into vinegar. That change is substantial because the wine and the vinegar are two different substances: they are not the same *sort* of thing. Aristotle calls *matter* what is capable of substantial change, i.e. what remains identical while the substance changes. The matter appears first in one form then in another. It is for this reason that Aristotle’s followers, without at this point betraying the spirit of the master, will say that the matter had the *substantial form* of wine and then acquired the *substantial form* of vinegar. The substantial form is what makes it the case that this wine is a substance of this kind. This ‘making the case’ is very different from the active ‘bringing about’ that produces the substance. Not to pay attention to this difference would amount to confusing the formal cause with the efficient cause. The substantial form provides what contemporary philosophers<sup>18</sup> often call a thing’s *criterion of identity* (which is what allows justifying that *this* wine is different from *that* beer and, in a different manner, that this wine yesterday is the same thing as that wine today). Matter provides a *principle of individuation*: it is what makes *this* beer distinct from *that other* beer although both drinks otherwise satisfy the same criterion of identity.

One question that arises is whether there must always be some substantial predicate that is true of matter that remains identical throughout a substantial change. In many cases it is clear that there is such a predicate: when for example a piece of copper is transformed into bronze, the matter undergoing a substantial change

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<sup>17</sup> Aristotle, *Physics*, III, ch. 1, 201a10-11.

<sup>18</sup> See D. Wiggins, *Sameness and Substance* (Oxford, 1980) and E.J. Lowe, *A Survey of Metaphysics* (Oxford, 2002).

remains a *metal* throughout. However, Aristotle<sup>19</sup> and later Aquinas held that nothing prevents matter from undergoing a substantial change such that no substantial predicate is true of it before, during and after the change. Such matter, called ‘prime matter’, cannot exist without form, even if it is not tied to a particular form. Similarly, no substantial form can exist without being constituted of matter. Aristotle’s doctrine does not attribute any ontological autonomy either to substantial forms or to prime matter; only concrete substances exist, and these substances cannot be conceived as *compositions* of substantial form and matter.<sup>20</sup> In this general framework, Aristotle raises the problem as to whether it is legitimate to conceive of a power that never gets realized.<sup>21</sup> If, for one reason or another, it is established in advance that the coat gets worn out before it is torn up, can it be said that it has ever had the *power* of being torn up? Aristotle made considerable efforts to justify the attribution of powers to things even if they are not exercised, against those who, like the Megarians, held that a power that is not exercised is a contradictory notion, and who concluded from this that a possibility should be identified with its realization. Possibilities exist only if they are realized and, in the end, something is possible now only if it is effective now. On this view, if Socrates is now sitting, it must be denied that he now has the power to stand later. Although Aristotle criticized this thesis, he was not able to provide a clear answer as to whether the possibility today implies the realization *one day or another*.<sup>22</sup>

Clearly, the whole debate revolves around the issue of the ontological status of powers: if a power precedes its exercise, if it constitutes an actual property of a thing, it is natural to wonder about the mode of being of such a mere *potentiality*. How does one conceive the mode of *existence* of a mere *possibility*?

#### *The Reification of Powers, Real Accidents and Substantial Forms at the Beginning of the 17<sup>th</sup> Century*

One solution to the problem is to lend quasi-substantial reality to powers. A power becomes *something* that acts. From the point of view of modern philosophy, this reification of power is characteristic of the late scholastic school. What exactly is this *reification* of which the moderns accuse the schoolmen? Certain texts of the

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<sup>19</sup> Whether Aristotle himself accepted the existence of prime matter is controversial. See *On Coming-to-be and Passing-away*, book I, ch. 4, 320a2 and book II, ch. 1, 329a32.

<sup>20</sup> This is not completely true for Aquinas who, mostly for theological reasons, holds that the substantial forms of humans, which he calls *souls*, can persist even while they are separated from the body.

<sup>21</sup> See Aristotle, *On Interpretation*, in Aristotle, trans. H.P. Cooke, *Categories, On Interpretation, Prior Analytics On Interpretation* (Cambridge, 1938), ch. 9. pp. 111-179.

<sup>22</sup> On this thesis, often called ‘the principle of plenitude’, see J. Hintikka, *Time and Necessity* (Oxford, 1973), ch. 5; S. Knuutila, *Modalities in Medieval Philosophy* (London, 1993), ch. 1 and J. Vuillemin, *Nécessité ou contingence* (Paris, 1984) chs. 1-3.

Spanish jesuit Suarez, author of a gigantic synthesis, both systematic and original, of scholastic knowledge, provide some essential keys for understanding the debate. Written at the beginning of the 17<sup>th</sup> century, Suarez' ontology is based on the distinction between substance and accident and his analysis of the notion of power and effectivity faithfully follows the Aristotelian tradition.<sup>23</sup> However, Suarez' analysis, accomplishing an evolution whose source can be found in medieval scholasticism, gives an important new twist to the understanding of the very notions of substantial form and accident, and particularly to that of quality.

Let us first consider the latter. A blade of a knife having a quality such as sharpness accounts for its operations of cutting. To a very general inquiry about the ontological status of powers, it is natural to reply that very often they are qualities. However, once this first reply has been given, a second question immediately arises: are qualities ontologically *independent* of the substances of which they are qualities? William of Ockham who had already raised this question in the 14<sup>th</sup> century, replied that certain qualities are ontologically independent but others are not. He has a simple criterion to ground this distinction: qualities are distinct things, *res distincta*, in case it is impossible to account for their acquisition or loss by a mere local movement. Thus, the geometrical forms of objects, e.g. their being straight or bent, are not distinct *res* because it is possible to explain their acquisition by the mere spatial shifting of the object's parts.<sup>24</sup> The same is true of the beauty of a thing, which depends on the relation between its parts. However, dispositions (in the sense in which one can say that someone is well disposed), habits (*habitus*) which are acquired powers, and natural capacities (*potentiae naturales*) sometimes need to be considered as distinct *res*: this is the case for the habits of will whose acquisition cannot be explained by any rearrangement of its parts (because the will has no parts); however, it is not the case of the disposition of health which can be explained by the simple proportion of humours.<sup>25</sup>

When Suarez takes up this issue, he maintains Ockham's distinction, among accidents in general and qualities in particular, between those that can and those that cannot be considered as entities truly distinct from the substance they inhere in. Thus, the quantity of a thing 'is not only a mode, but something distinct from the substance'.<sup>26</sup> Suarez calls such properties that can be separated from their

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<sup>23</sup> F. Suarez (1597), 'Disputationes Metaphysicae', in C. Berton (ed.), *Opera omnia*. Editio nova (Hildesheim, 1998), Disputatio 43, XXVI, pp. 633-663.

<sup>24</sup> See William of Ockham, *Summa logicae*, in P. Boehner, G. Gal and S. Brown (eds), *Opera philosophica* (New York, 1980), I, 180 (Pars I, Cap. 55) and William of Ockham, trans. A.J. Freddoso, *Quodlibetal Questions*, 2 vols. (New Haven: Yale University Press., II, 597 (Seventh Quodlibet, Question 2, vol. IX, pp. 707-708, Saint Bonaventure University, New York, 1980)

<sup>25</sup> See Ockham, IX, p. 94 (First Quodlibet, Question 18); trans. Ockham (1991), I, 80.

<sup>26</sup> 'Quantity is therefore not so much a mode, as a thing distinct from the substance (*ergo quantitas non est tantum modus, sed res distincta a substantia*)', F. Suarez, Disputation 40, XXVI, §8, p. 535. The context is the mystery of the Eucharist. To account

substance, *real accidents*. By contrast, those properties of substances that cannot be separated from them are mere *modes* of those substances. A mode exists only by inhering in a substance. Take away the inherence and you have taken away the mode. The important point is that the separability of two ‘entities’ is taken to be sufficient for judging that there is a *real distinction* between them, not only a *modal*<sup>27</sup> distinction, and at the same time for saying that a mode is not a *res* because it is not separable.<sup>28</sup> Suarez takes it to be certain that the powers of a thing belong to the category of real accidents, not to that of modes, which means that powers are really distinct from substances.<sup>29</sup>

According to Descartes, substantial forms ‘were introduced by philosophers solely to account for the proper actions of natural things, of which they were supposed to be the principles and bases (*principium et radix*)’.<sup>30</sup> On this point, Aristotle and the scholastics would agree. It is indeed in this form, that, in Suarez’ words, ‘all that variety of accidents and powers has its root (*radix*) and a certain unity’.<sup>31</sup> Therefore, a substance must be thought to possess a substantial form that is ‘distinct from its accidents’<sup>32</sup> (and its powers) and allows to account for them. Here, however, scholastic doctrine adds an important new twist to Aristotle’s analysis. Indeed, Suarez takes matter and substantial form to be both entities that can exist in separation one from the other<sup>33</sup>, although they call for each other to compose a complete and concrete substance. Furthermore, the substantial form surreptitiously changes its status as a criterion of identity of the composed substance and the actions it is capable of accomplishing, in other words its status as merely formal cause, to become the *efficient* cause of that composed substance: it

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for it, one must suppose, says Suarez, that God can separate the quantity of the substances bread and wine from those substances themselves.

<sup>27</sup> One of Suarez’ great achievements is to have provided a systematic and original presentation of what may be called the theory of distinctions. See Suarez, Disputation 7, XXV, 250-274.

<sup>28</sup> ‘Hence there exist, in created things, certain modes affecting them whose nature seems to consist in this, that they are not sufficient by themselves (*per se*) to constitute a being (*ens*) or an entity (*entitatem*) in the nature of things, but intrinsically require an entity that they affect and without which they can in no way (*nullo modo*) exist.’ Suarez, Disputation 7, 1, §18, p. 256)

<sup>29</sup> Suarez says that the ‘proximate power of acting and operating (*proximam virtutem agendi et operandi*) is distinct from its substance and is consequently an accident’ (Suarez, Disputation, 18, 3, § 17, trans. p. 103).

<sup>30</sup> Descartes, Letter to Regius, January 1642, AT III, p. 506; trans. Descartes (1984), III, p. 208.

<sup>31</sup> Suarez, Disputation, 15, 1, § 7, p. 499.

<sup>32</sup> Ibid.

<sup>33</sup> Suarez, Disputation, 15, 5, §§ 1-2, p. 517/8.

becomes, in Suarez' own words, its 'principle of operation'.<sup>34</sup> The substantial form that explains the operations of the complete substance is now considered as an entity *distinct* from it. To say that opium has the power to make people sleep, means that it contains a separate entity making it what it is: it is the opium's substantial form that acts on the patient after it has been ingested. To use one of Suarez' own examples, the fact that heated water cools down when the heat source has been removed, can be explained by the existence of a substantial form that is the active source of the water's tendency to cool down instead of remaining at the temperature it has acquired.<sup>35</sup> The ultimate source of a substance's powers lies in its substantial form whose status is first that of a substance though an incomplete one, and second and above all that of an agent.<sup>36</sup>

### *Descartes and Boyle*

Robert Boyle, Descartes' and Bacon's heir and Locke's direct source of inspiration, was the most eloquent and in many respects most fascinating advocate of the new anti-scholastic philosophy. The attack launched both by Descartes and Robert Boyle is mostly directed at the 'quasi-substantialisation' of qualities and at the authentic substantialisation of substantial forms.

If there is one key element in the wide-reaching conceptual change introduced by Descartes, it is the distinction between the mental and the physical, in other words *dualism* of thought and extension replacing the distinction between form and matter constitutive of Aristotle's *hylomorphism*. This new conception of the relation between mind and body is at the source of Descartes' relentless criticism of the scholastic theory of the action of physical substances. In retrospect, Descartes appears to have been right in rejecting the idea that physical substances are literally *animated* by an inner soul, and that it is this soul which gives them the capacity to act. So let us look a little closer at the way in which Descartes and Boyle criticize the notions of real accident and substantial form.

Descartes puts forward two fundamental arguments against the notion of real accident.<sup>37</sup> The first and doubtless most famous argument consists in accusing Aristotle of 'metaphysical paganism'.<sup>38</sup> by attributing to each substance an internal

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<sup>34</sup> 'In material things, it appears that form is a principle of operation (*principium operandi*), which is a formal and *active* principle). (Suarez, Disputation 15, 11, § 4, p. 559, our italics).

<sup>35</sup> Suarez, Disputation 15, I, 8, p. 500.

<sup>36</sup> To explain how, in the concrete actions of a complete substance, the substantial form and the real qualities are associated in accomplishing certain operations is a complex issue, and not necessary to pursue here.

<sup>37</sup> On this point, as well as about substantial forms, see the excellent work by M. Rozemond, *Descartes's Dualism* (Cambridge, 1998), ch. 4. See also E. Gilson, *Etudes sur le rôle de la pensée médiévale dans la formation du système cartésien* (Paris, 1967), p. 141ff.

<sup>38</sup> The expression is ours, not Descartes'. However, Malebranche can be found accusing the peripateticians and more generally the ancients, of 'paganism'. See

capacity of change, he populates the universe with so many little souls. Let us take the case of heaviness, which is the only quality Descartes really analyses.<sup>39</sup> This quality belongs to the essence of a body and is independent of its extension. It is somehow united to that extension though it does not depend on it. This is shown by the fact that it can produce its effects by being localised at one point of the body: if the body is suspended on a thread, it seems as if its heaviness acts entirely at the point at which the body is suspended, a point that may ideally be reduced to a 'mathematical point'. For Descartes, this conception amounts to considering heaviness as a little soul: just as a soul, it appears to be both present 'in each part' of the body at the same time and capable of producing its entire action in each of these parts, just as a human agent does when she moves one of her members. True, heaviness also appears to us as a quantity that is measurable, divisible and therefore quantifiable, just as extension. But for Descartes this only shows that the scholastic real qualities are the result of a regrettable confusion between mental properties and purely bodily properties. If we are inclined to attribute a real quality to the heavy body, this is because we confusedly attribute to it something equivalent the faculty of knowledge, which really belongs only to mankind. This faculty is thought to allow the body to 'know' where it should aim its movement, namely to the centre of Earth. This conception results from illegitimately projecting on the relations between simple physical bodies, a model of movement that fits perfectly well to human action where the soul acts on the body (thereby inducing movement): the relations between simple physical bodies can be given a fundamental explanation by the laws of collision.<sup>40</sup> In sum, by attributing to the body something that is equivalent both to a capacity of representation and to a faculty of volition, we fall prey to a spontaneous and naive form of *anthropomorphism*. No body, as a body, has any *internal* power of moving itself or of acting on other bodies.

Descartes' second argument is at least as strong as the first, which suffers from being applicable only to the quite specific case of heaviness. It consists in rejecting the very concept of a real quality. Recall that according to late scholastic doctrine, separability was considered as sufficient condition for the existence of two distinct *res*. However, being a *res* did not imply being a *substance*. This is precisely the logical point of the doctrine of real *accidents* or *qualities* that Descartes rejects. From his point of view, the distinction between two *res* makes them necessarily two substances, for they can clearly and distinctly be conceived as independent. If indeed we 'imagined [...] to be real' the 'various qualities of bodies such as

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Malebranche, 'Eclaircissements sur la recherche de la vérité', book VI, 2nd part, ch. 3, p. 643ff., trans. p. 446ff.).

<sup>39</sup> See Replies to the Sixth Set of Objections, AT VII, pp. 441-442 (Latin) and IX, pp. 240-241 (French); trans. Descartes (1984), II, pp. 297-298.

<sup>40</sup> 'So I think that we have hitherto confused the notion of the soul's power to act on the body with the power one body has to act on another.' (Letter to Elizabeth, 21 May 1643, AT III, p. 667, trans. Descartes (1984), III, 219)

heaviness, heat, etc.’, we thereby imagined them ‘to have an existence distinct from that of bodies, and *so to be substances*.’<sup>41</sup> Now, ‘it is completely contradictory that there should be real accidents, since whatever is real can exist separately from any other subject; yet anything that can exist separately in this way is a substance, not an accident.’<sup>42</sup> The very notion of a real accident is absurd because it attributes two contradictory properties to one entity: to be an accident and therefore to be ontologically dependent, and to be a substance, and therefore to be ontologically independent.

Boyle criticizes the notion of real accident in a similar way. Boyle defends a ‘corpuscular philosophy’: all so-called ‘secondary’ or ‘non-mechanical’ qualities (*manifest* qualities, such as cold and hot, *occult* qualities such as magnetism and electricity, or *sensible* qualities such as colours) attributed to things must ultimately be explained by the fundamental ‘primary’ or ‘mechanical’ qualities of the basic material units of composition, such as form, size, movement and texture. Boyle refrains from saying whether corpuscles are in principle divisible, which makes his position weaker than atomism, which holds that those basic units are indivisible. Texture plays a particularly important role because it is the particles’ *disposition*<sup>43</sup>, taken in the structural sense of geometrical configuration, which is in many cases supposed to account for the operations of the agent. The issue that interests Boyle is not whether these properties are physical or not (they certainly are), but rather in which ontological category they belong: are they substances or accidents? The doctrine of real accidents, for Boyle, is a contradiction in terms: it construes qualities as substances that ‘may exist separate from all matter whatsoever’<sup>44</sup>, as entities that do not need other entities to exist, hence really as substances. Note that Boyle’s objection against the scholastic doctrine is, in his own view, grounded on a well established Aristotelian distinction. It is of no fundamental importance whether these entities are spiritual or *physical*: even a real physical accident is an absurdity. The important point is that qualities are *modes* (or *moods*) of matter rather than entities, be it material entities, that are *superadded* to this matter.

What about substantial forms? The very notion of real quality is rejected because it contains a straightforward logical contradiction, as we have just seen. Such is not the case with the notion of substantial form whose incoherence is established in a

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<sup>41</sup> Letter to Elizabeth, 21 May 1643, AT III, p. 667; trans. Descartes (1984), III, 219; italics ours.

<sup>42</sup> Replies to the Sixth Set of Objections, AT VII, 434-435 (Latin) and AT IX, 234-235 (French); trans. Descartes (1984), II, 293.

<sup>43</sup> On this meaning of the word ‘disposition’, which has nothing to do with the *dispositio* as capacity, see Descartes, *Les Principes de la philosophie*, IV, § 198, AT IX, p. 317; trans. Descartes (1984), I, 285. Descartes, *Les Principes de la philosophie*, trans. E.S. Haldane and G.R.T. Ross, *The Principles of Philosophy*, in *The Philosophical Works of Descartes*, vol. 1 (Cambridge, 1912), pp. 201-302.

<sup>44</sup> R. Boyle (1772, p. 16). ‘*The Origin of Forms and Qualities*, in *The Works*, III, ed. by Thomas Birch, (Hildesheim, 1966), p. 16.

more indirect fashion. Even Descartes, anxious not to overly offend the authority of the School, occasionally uses the expression ‘substantial form’ to qualify the thinking substance. Nevertheless, Descartes does contest that the notion it expresses is well grounded, and as he himself says, his criticism is both metaphysical and theological.<sup>45</sup> The scholastic tradition generally distinguishes the substantial form of humans, whose soul is created by God, and the substantial forms of natural substances, that come into existence through natural process; to this difference in origin corresponds a difference in destiny, insofar as the human soul survives the disappearance of the body to which it gives form, whereas all other substantial forms disappear together with the bodies to which they are attached. This difference in origin and destiny does not prevent the scholastics from considering that *all* substantial forms are *separable* from matter: this separability is thought to be *natural* in the case of the human soul, but requires divine intervention in the case of other substantial forms. However, as we have already seen, in the scholastic doctrine, separability does not imply substantiality, such that it is possible to say both that substantial forms are separable and that they are nevertheless not themselves substances. Nevertheless, for reasons arising from his transformation of formal cause into a principle of operation and of unity of the substance, Suarez ends up considering separability not only as the sign of a real distinction, but also of substantiality.

This is precisely the idea that Descartes rejects, just as he does in the case of real accidents. For him, as we have seen, separability is a condition sufficient for substantiality; hence, *every* substantial form must be considered as a separate substance. Therefore, there is no logical ground on which to justify the distinction between natural substantial forms and souls, and the distinction between natural separability and divine separability is simply not relevant. Now, for Descartes who attributes real separability only to the thinking substance, all non material substances must be considered to be really separate from matter. This means that the schoolmen attribute to substantial forms in general a property that belongs only to thought, so that the idea of non human substantial forms is the result of a regrettable confusion between thought and matter (and therefore, according to Descartes, extension). In this way, Descartes again justifies the idea that attributing a substantial form to natural, hence physical, things, is *ipso facto* giving material bodies a soul that alone accounts for their behaviour, their capacity to act and to undergo action in the way they do, and this argument once more accuses the scholastic doctrine of anthropomorphism.

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<sup>45</sup> We rely here essentially on the long letter to Regius from January 1642, AT III, pp. 491-510; partial trans. Descartes (1984), III, 205-209.

This accusation can also be found in Boyle's writings;<sup>46</sup> however, he makes the objection on purely conceptual grounds: if real accidents are considered to be detached from substances, they have been made substances and *therefore* substantial forms. Substantial forms are treated exactly like real accidents. For Boyle, contrary to what we have seen in Descartes' argument, it does not matter whether a substantial form is physical or not. However, this consideration is supplemented by a nominalist thesis. Indeed, a substance in the ordinary sense of the term (hence with the exception of the fundamental elements of reality, which are the particles) is nothing else but an association of qualities.<sup>47</sup> This does not prevent Boyle from thinking that, at a deeper level of analysis, these qualities themselves are grounded on primary qualities of the particles that really constitute a substance. Every substantial change can be explained by a local displacement of the material parts of the substance.<sup>48</sup>

*Elimination and/or Reduction of Powers*

Does all this mean that the notion of power has no longer any role to play? Insofar as Descartes and the tradition following him is concerned, it is undeniable that the notion of power is simply *eliminated*. This is because a power is a power to act, whereas the traditional category of action does not have any place in Descartes' physics. First, every change is reduced to locomotion.<sup>49</sup> Second and most important, Descartes holds that '*motion is the transfer of one piece of matter [...] to the vicinity of other bodies [...]. I say "the transfer" as opposed to the force or action which brings about the transfer, to show that motion is always in the moving body as opposed to the body which brings about the movement*'.<sup>50</sup> No material body possesses the internal power of motion or rest, as the critique of substantial forms and real qualities has shown.<sup>51</sup> Therefore, no body can act, and in particular

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<sup>46</sup> 'Now when any body is referred to any particular species (as of a metal, a stone, or the like) [...] most of the writers of physicks have been apt to think, that besides the common matter of all bodies, there is but one thing that discriminates it from other kinds, and makes it what it is, and this, for brevity's sake, they call a form: which, because all the qualities and other accidents of the body must depend on it, they also imagine to be a very substance, and indeed a kind of soul [...]' R. Boyle, *The Origin of Forms and Qualities*, p. 27.

<sup>47</sup> Boyle, *ibid.*, pp. 27-29.

<sup>48</sup> Boyle, *ibid.*, pp. 37-38.

<sup>49</sup> See *Principles of Philosophy*, II, § 23, AT IX, p. 75; trans. Descartes (1984), I, 232/3.

<sup>50</sup> *Principles of Philosophy*, II, § 25, AT IX, p. 76, trans. Descartes (1984), I, 233, emphasis Descartes'.

<sup>51</sup> This is also Descartes reason for rejecting the Aristotelian and scholastic distinction between natural and violent movement, i.e. between movements in agreement with and movements in opposition to the internal principle of change. See Descartes, *Principles of Philosophy*, II, § 37, AT IX, p. 85; trans. Descartes (1984), I, 241.

act *on other bodies*. Motion is only a mode or state of the mobile body, which cannot be attributed to any other substance, neither to an internal substance (which would make it a soul), nor to an external material substance. As Martial Gueroult notes, Descartes leaves ‘force as a faculty of a subject, as a power to bring about a given effect, entirely aside, and takes into account only the acting force that is identified with its geometrically expressible effect’.<sup>52</sup> However, by saying that force is always active or that power is always effective, one identifies power with its exercise and therefore makes nonsense of the distinction between power and exercise, which is necessary to give sense to the notion of power itself.

The writings of Boyle or Locke who takes inspiration from him, show however that this elimination of powers is not at all straightforward. From the fact that the qualities which account for the powers of substances to act are not real accidents, it does by no means follow that they are fictions; one might just as well infer from the fact that Socrates’ size is not a substance, that it is not real. Here Boyle and Locke hit upon a problem that many contemporary philosophers try to solve (the present volume being intended to bear witness of some such efforts). In their texts, a crucial distinction is alluded to but never explicitly stated, between the power to accomplish a certain operation on one hand, such as the power of water to dissolve sugar, and on the other hand the property or quality (whose nature to reveal is the task of chemistry) that explains or accounts for that power, that capacity of water to dissolve sugar. That quality is permanent and exists clearly before the substance exercises its power. It constitutes what is now called the *categorical basis* of the power.<sup>53</sup> Now, the question arises *whether a power is identical with its categorical basis*. There certainly is a *conceptual* distinction (in contemporary vocabulary, one may also call it a *semantical* distinction) between a power and its categorical basis (knowing that water has the power to dissolve sugar is not itself sufficient for knowing the chemical composition of water). However, is this enough to show that there also exists an *ontological* distinction between them, a difference *in the things themselves*? Locke’s texts are far from clear on this point. Let us take a paradigmatic example of what one may call a *dispositional property*, i.e. a property that can be described in terms of its power to produce certain characteristic effects, which does not yet prejudge the issue of whether the property is identical with that power: colour. Any analysis of colour perception inevitably encounters the following classical problem: do they exist independently of being perceived? (This is the question of *esse est percipi*). Locke gives an affirmative answer<sup>54</sup>, and takes, as does Boyle, the example of the porphyry that is white and red in daylight and that is taken to a dark cave. It nevertheless remains coloured, says Locke, because the colour of the porphyry is merely its disposition to produce in a perceiving

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<sup>52</sup> M. Guéroult, *Leibniz. Dynamique et métaphysique* (Paris, 1967), p. 67.

<sup>53</sup> On this issue, see among others, the contributions by Mumford, Kistler, Tiercelin to this volume.

<sup>54</sup> J. Locke, P.H. Nidditch (ed.), *An Essay concerning Human Understanding* (Oxford, 1975), II, 8, § 19.

subject the visual experience of red (the *idea* of red), and this disposition exists even when it happens not to be exercised. Locke does not ask explicitly whether one can *reduce* and more particularly *identify* this disposition with its categorical basis which he takes to be a ‘configuration of particles’. However, it seems that he makes this reduction because he proceeds by writing: ‘whiteness or redness are not in it [the Porphyre] at any time, but such a texture, that hath the power to produce such a sensation in us’.<sup>55</sup> White is (identical with) a disposition, but also (identical with) a texture. Therefore, the disposition is (identical with) a texture. In fact, things are a good deal more complicated because, as the quoted text shows, it is not the porphyry itself that is said to exercise the power to produce certain visual sensations, a power that could be identified with a certain quality of the porphyry, i.e. its texture, but rather the quality of the porphyry...

One can find the same hesitation in Boyle’s writings.<sup>56</sup> However, the texts of the English scientist and philosopher contain traces of a thesis, never explicitly stated, that will soon get lost and is only rarely found in contemporary analyses of causal powers, namely the thesis that power is a *relational* notion. Boyle offers the example of the opening power or ‘virtus aperitiva’ possessed by a key, or more precisely, the capacity of a lock to be opened by a key.<sup>57</sup> Think of Tugal Cain, the first blacksmith according to the biblical tradition. He makes a lock, the first one ever to exist. The lock can be described in a purely structural way, by the relative position of its parts. The key does not yet exist. However, let us imagine that he now makes a key that opens the lock. Once the key has been made, the lock acquires the power to be opened by the key (which therefore itself has the power to open the lock).

Boyle argues that there is no power of the lock that gets added to the mutual position of its parts (the categorical basis of the power), because for the lock to acquire that power, no one has in any way acted on the lock (therefore it has not acquired any additional property in this sense). Boyle seems to rediscover at this point a notion that was familiar in the ancient and scholastic tradition: there is no relational change. Socrates is taller than Theaitetus is as a child. However, Socrates is smaller than Theaitetus as an adult. However, Socrates has not acquired any additional property, because it is precisely by not changing in size that he becomes smaller than Theaitetus. Only Theaitetus undergoes a change. But Boyle, more or less explicitly, adds an idealist touch to this consideration: the property to be smaller than Theaitetus is relational, *which implies* that it is not real at all, but

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<sup>55</sup> Ibid.

<sup>56</sup> On Boyle, see in particular P. Alexander, *Ideas, Qualities and Corpuscles* (Cambridge, 1985) and P.R. Anstey, *The Philosophy of Robert Boyle* (London, 2000). More recently, S. Shoemaker and G. Molnar have discussed Boyle’s key-lock problem. See S. Shoemaker, ‘Causality and Properties’ in D.H. Mellor and A. Oliver (eds), *Properties* (Oxford, 1997), p. 243 and G. Molnar, S. Mumford (ed.), *Powers. A Study in Metaphysics* (Oxford, 2003), p. 102.

<sup>57</sup> Boyle, *The Origin of Forms and Qualities*, pp. 18-19.

rather the result of a comparison the mind operates between Socrates and Theaitetus. The same is true of the power of the lock: because it is only by virtue of its relation to the key that one attributes this property to it, one should conclude that the only ground of the power lies within the mind contemplating it and associating it to the key.

However, one might also draw a different conclusion, which is suggested by some passages of Boyle's own text. What the case of the first lock and key shows is that we cannot have the power of the lock to get opened by the key without the *related* power of the key to open the door. In short, it is logically impossible that there be only one power in the world. A power exists only in *relation* to another power. But if power is relational in nature, it cannot be simply identified with its categorical basis, for that basis clearly belongs only to the thing itself that possesses the power and can be attributed to it independently of whether any other thing exists: the lock itself has a certain physical conformation that cannot be altered by the mere existence of the key *in addition to it*. Locke himself recognizes the existence of both active and passive powers<sup>58</sup>, although it is not clear whether he considers them to depend on each other. Only a few decades later, Thomas Reid finds the very idea of a passive power unintelligible.<sup>59</sup> Indeed, *relative beings* have always been a major challenge for philosophical analysis.<sup>60</sup>

Leibniz, a critical reader of Locke, never conceived of a disposition without the context of its 'actuation', to use one of his favorite terms for designating the effectiveness of a power. As Hide Ishiguro<sup>61</sup> has noted, if a disposition such as tenderness reduced itself to the internal state of a particular, it would follow that it is possible that someone manifest tenderness independently of the circumstances making this manifestation intelligible. However, would we understand a person describing a sudden whiff of tenderness towards a glass of milk? A disposition is always attributed on a background of circumstances *appropriate* to its manifestation. Therefore, it cannot be reduced to a strictly internal state of its bearer.

### *The Emergence of Dynamism*

There is another respect in which Leibniz plays a key role. As certain historians of science have noted, the materialist, corpuscular and mechanist analysis of

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<sup>58</sup> See, e.g., Locke, *An Essay concerning Human Understanding*, II, ch. 21, §2.

<sup>59</sup> 'I conceive passive power is no power at all.' T. Reid, *Essays on the Active Powers of the Human Mind* (Cambridge, 1969), p. 23.

<sup>60</sup> On the history of the analysis of this notion in the Middle Ages, see M.G. Henninger, *Relations* (Oxford, 1989). The notion of relation has recently been analyzed by V. Descombes, *Les Institutions du sens* (Paris, 1996), chs 16 and 17.

<sup>61</sup> See H. Ishiguro, *Leibniz's Philosophy of Language* (Cambridge, 1990), p. 111. Leibniz uses the example of tenderness in *New Essays*, book II, ch. 22, § 10, GP, V, 199/200; trans. Leibniz (1981), 215.

Descartes and Boyle never succeeded in entirely extinguishing another tradition, that of a ‘dynamical’ conception of matter, of which Gilbert, with his *De Magnete*<sup>62</sup>, was a somewhat naïve ‘precursor’ and which Leibniz has contributed to making respectable. Indeed, Leibniz can be seen to take up faithfully Aristotle’s analysis of change, and to state in particular that ‘power (*puissance*) [...] in general’ is ‘the possibility of change’, that change ‘is action in one subject and passion in another’, and that therefore there are ‘two powers, one active and one passive’.<sup>63</sup> However, beyond the fact that these traditional elements become integrated into a general metaphysical framework (that of pre-established harmony) that partially alters their meaning, the problems raised by the new physics lead Leibniz to elaborate on the distinction between active and passive power, in order to account for the notion of *force*. For matter in itself (which for Leibniz is equivalent to what is elsewhere called *mass*) is purely passive and could not by itself be capable of acting, in particular of moving. It only accounts for bodies’ impenetrability and inertia. To make sense of the idea that this prime matter has the force of moving, it must therefore be attributed to something analogous to a soul or a substantial form. It thereby becomes secondary matter.<sup>64</sup> However, this theory need not necessarily be interpreted as a return to the separate substantial forms of the late scholastic tradition. Manifestly, Leibniz aims at a conceptual distinction between a simple (purely passive) capacity and what he calls a *tendency*<sup>65</sup>, which is not yet the act itself, but something followed by the act if all obstacles that might hinder its coming about are taken away. The idea of a tendency or force is also one of the crucial points of Leibniz’ critique of Descartes’ account of the nature of movement. To the extent that one conceives of movement, as does Descartes, in a purely geometrical way that reduces it to the successive positions occupied at each instant by the moving object, it is impossible to distinguish, at a given moment, between Zeno’s arrow being at rest and Zeno’s arrow moving.<sup>66</sup> In fact, the arrow bears *at each instant* a tendency to move towards a given direction *later on*.<sup>67</sup>

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<sup>62</sup> On W. Gilbert, see, e.g., the presentation by E.J. Dijksterhuis, *The Mechanization of the World* (Princeton, 1985), p. 39ff.

<sup>63</sup> Leibniz, *New Essays on Human Understanding*, II, ch. 21, §1, GP V, 155; trans. Leibniz (1981), 169. E.J. Dijksterhuis, *The Mechanization of the World*.

<sup>64</sup> See *Nature Itself*, GP IV, p. 510 and p. 512; trans. Leibniz (1998), pp. 216-218.

<sup>65</sup> See, e.g., *Nature Itself*, G. IV, p. 512; trans. Leibniz (1998), p. 218; *New Essays on Human Understanding*, II, ch. 21, §1, trans. Leibniz (1981), p. 169, and *Theodicy*, § 87, G IV, p. 149.

<sup>66</sup> Leibniz, *Nature Itself*, §13, G IV, p. 513; trans. Leibniz (1998), pp. 218-219.

<sup>67</sup> All this is related to the intricate issues of the relativity of movement and the nature of the relations between the quantity of movement ( $mv$ ) and the ‘force vive’ ( $mv^2$ ). See, e.g., Leibniz, *Discourse on Metaphysics*, § 18, GP IV, 444; trans. Leibniz (1998), pp. 71-72. On the history of the problem raised by the possible relativity of movement, see J.B. Barbour, *Absolute or Relative Motion* (Cambridge, 1989), vol. 1 and on the problem of the status of the ‘force vive’, see the excellent M. Spector, ‘Leibniz vs. the Cartesians on Motion and

This critique of cartesian geometrism leads Leibniz in the end to reject the primacy of extension in the account of matter insofar as it is in motion. Ultimately, extension itself gets assigned a derivative status with respect to force. What is fundamental in a corporeal substance is not its ‘extension’, but rather its capacity to act on other substances and to resist the action of other substances. According to some<sup>68</sup>, Leibniz anticipates, at a metaphysical level, a line of thought that will find its physico-mathematical expression in the notion of (electromagnetic) field, by Faraday and above all Maxwell<sup>69</sup> in the 19<sup>th</sup> century. In their analysis of the intellectual evolution culminating in the notion of field, certain commentators have noted that Newton had clearly anticipated the necessity of such a notion, whereas from a philosophical perspective, Kant<sup>70</sup> (after Boscovich) had followed the radical implications of this point of view to their end, by conceiving physics as grounded, rather than on an extension sprinkled with bodies, on two fundamental forces, attraction and repulsion.<sup>71</sup>

However, this perspective on the philosophy of science should not hide the fact that Leibniz, Newton and Maxwell raised a general ontological problem: is it possible to accept the existence of causal powers without any categorical basis?<sup>72</sup> There are many reasons to ask this question, independent of the problem of the nature of the notion of field in physics. But it is safe to say that one of the historical sources of the problem lies in the metaphysical interpretation of the notion of force, as it has developed in the scientific context.<sup>73</sup>

Although Leibniz obviously does not possess the notion of field, his thought plays a central role for a different reason. Although he takes up, as we have already seen, Aristotelian language, his metaphysics does not allow a substance to act on any other substance, which excludes every form of transitive causation. Nevertheless,

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Force’, *Studia Leibniziana*, 7, n° 1 (1975): 135-144., as well as R. Dugas, *La Mécanique au 17<sup>ème</sup> siècle* (Paris, 1954), p. 477ff.

<sup>68</sup> E.g., R. Harré and E.H. Madden, *Causal Powers* (Oxford, 1975), p. 167.

<sup>69</sup> Faraday was a great physicist and experimenter of the 19<sup>th</sup> century; Maxwell, a physicist sometimes considered to be on a par in importance with Newton, unified the theories of electricity and magnetism, taking his inspiration from Faraday’s discoveries, by constructing a powerful mathematical formalism that allowed him to master the notion of field. However, it should be noted that he tried to provide a mechanical model of the field.

<sup>70</sup> See Kant, chapter II, pp. 40-94.

<sup>71</sup> On all this, see L. Bloch, *Les Origines de l’Ether et la physique de Newton* (Paris, 1908) and J. Vuillemin, *Physique et métaphysique kantienne* (Paris, 1955), in particular p. 148ff. On the 19<sup>th</sup> century and the beginning of the 20<sup>th</sup>, see O. Darrigol, *Electrodynamics from Ampère to Einstein* (Oxford, 2000).

<sup>72</sup> This is one of the issues that is the object of contemporary research. We shall come back to it later in this introduction.

<sup>73</sup> R. Harré is one of the first philosophers to have brought together the general metaphysical issue of the nature of powers with the history of science and contemporary scientific practice, in particular in quantum physics. See, e.g. R. Harré, ‘Is There a Basic Ontology for the Physical Sciences?’, *Dialectica*, 51 (1997): 17-34.

contrary to Descartes or Malebranche, he does not conclude from this that substances have no power to act, but rather that their action is immanent to the substance. Thus, every state of the substance is a consequence of its internal activity.<sup>74</sup> The ‘connection (*liaison*)’<sup>75</sup> and the correspondence between the apparent action of the agent on the patient (the opium’s action on man) and the apparent passion the patient undergoes on behalf of the agent (the man’s falling asleep that is brought about by the opium) reflect a general order of nature whose institution is of divine origin (this is Leibniz’ ‘pre-established harmony’). Here we have the beginning of the idea that causation *between* substances is first of all grounded on the existence of a *law*, an idea that will progressively be detached from its religious origin.

### The Appearance of the Notion of Law

We hope that our brief presentation has shown to what extent it is an oversimplification of the history of the concepts of power and disposition to only say that they have fallen prey to Descartes’ attack against the application of the concept of substantial form to substances other than the human soul. Boyle and Locke propose to account for the powers of macroscopic bodies by attributing properties (‘primary qualities’) to their microscopic constituents, whereas the ‘dynamical’ conception of matter, such as that of Leibniz which led to the scientific notion of field, conceives all substances in terms of their powers and dispositions. Nevertheless, since the 17<sup>th</sup> century the use of these concepts has become marginal both in metaphysics and in philosophy of science. This is partially due to the fact that, in addition to Descartes’ critique, the use of the notion of cause in scientific *explanation* has also been questioned. The new experimental conception of science has given rise to a new conception of scientific explanation, in which the search for causes is considered to go beyond the legitimate reach of scientific enquiry. Since Galileo, the Aristotelian paradigm of explaining natural phenomena by the knowledge of their causes has been replaced by the nomological<sup>76</sup> paradigm of explanation. Without yet using the word ‘law’, Galileo

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<sup>74</sup> ‘It can therefore be said, in a way, and in a good sense [...] that one particular substance never acts on another particular substance any more than it is acted on by it. For consider: what happens to each one is only a consequence of its idea or complete notion and nothing else [...]’ Leibniz, *Discourse on metaphysics*, § 14; GP iv, p. 440; trans. Leibniz (1998), p. 67.

<sup>75</sup> Leibniz, *Discourse on metaphysics*, § 14; GP IV, p. 440; trans. Leibniz (1998), p. 67.

<sup>76</sup> The word ‘nomological’, from the Greek ‘nomos’ – the law – and ‘logos’ – the doctrine, is the adjective corresponding to the noun phrase ‘law of nature’. A nomological statement is a statement (i.e. a sentence uttered on a given occasion) expressing a law of nature.

assigns the task of searching for causes to metaphysics, where it is condemned to remain victim of the arbitrariness of the different doctrines. According to the modern conception of science, inaugurated by Galileo, scientific explanations must be based on what is accessible to observation and experiment: this includes the regularities found among natural phenomena, but not their causes. ‘The present does not seem to be the proper time to investigate the cause of the acceleration of natural motion concerning which various opinions have been expressed by various philosophers [...]. At present it is the purpose of our Author merely to investigate and to demonstrate some of the properties of accelerated motion (whatever the cause of this acceleration may be) [...]’.<sup>77</sup> Henceforth, the concept will be associated with the postulate of an obscure entity that escapes observation and therefore experimental control. The new conception of explanation can be found expressed in Berkeley: ‘It is not, however, in fact the business of physics or mechanics to establish efficient causes, but only the rules of impulsions or attractions, and, in a word, the laws of motions, and from the established laws to assign the solution, not the efficient cause, of particular phenomena’.<sup>78</sup> Rather than as a search for its causes, the explanation of an event or phenomenon is now conceived of as a demonstration that it belongs to a regular sequence of events or phenomena of the same type. By conceiving natural regularities as the expression of underlying laws, the fact that a singular phenomenon abides by a certain law, suffices to explain it: one has accounted for the phenomenon as soon as one has shown that it had to come about by virtue of a law of nature. Auguste Comte expresses a similar idea when he opposes mysterious causes to laws that are transparent to the mind because they are accessible to experience: ‘The fundamental revolution that characterizes the virility of our intelligence consists essentially in substituting everywhere, for the inaccessible determination of causes properly speaking, the simple search for laws, i.e. of the constant relations that exist between observed phenomena. Whether we are concerned with the smallest or with the most sublime effects, those of shock and heaviness or those of thought and morality, we can really know only the different mutual relations characterizing their accomplishment, without ever penetrating the mystery of their production’.<sup>79</sup>

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<sup>77</sup> G. Galilei (1638), ‘Discorsi e dimostrazioni matematiche intorno a due nuove scienze’, in *Le Opere di Galileo Galilei* (Firenze, 1898), p. 202 and trans. H. Crew and A. de Salvio, *Dialogues Concerning Two New Sciences* (New York, 1963), p. 160. On Galileo’s conception of causation and explanation, see E. Yakira, *La causalité de Galilée à Kant* (Paris, 1994).

<sup>78</sup> G. Berkeley ‘Of Motion (De Motu)’, in A.A. Luce and T.E. Jessop (eds), *The Works of George Berkeley, Bishop of Cloyne*, (London, 1951), § 35, p. 40.

<sup>79</sup> A. Comte, *Discours sur l’esprit positif* (Paris, 1983), pp. 19-20. ‘La révolution fondamentale qui caractérise la virilité de notre intelligence consiste essentiellement à substituer partout, à l’inaccessible détermination des causes proprement dites, la simple recherche des lois, c’est-à-dire des relations constantes qui existent entre les phénomènes observés. Qu’il s’agisse des moindres ou des plus sublimes effets, de choc et de pesanteur comme de pensée et de moralité, nous n’y pouvons vraiment connaître que les diverses

*Hume's analysis of causation and the disappearance of the notion of power*

Hume attacks the traditional concept of cause and the obscure notion of a power necessarily generating effects from a different angle: instead of banishing the concept of cause itself, Hume proposes to purify it by isolating its rational core. Hume does not say that there are no causes or that causation defies rational understanding. Rather, Hume's project is to conceive of causation in a new way, as a *relation* satisfying certain constraints. According to his famous definition, a cause is 'an object precedent and contiguous to another, and where all the objects resembling the former are placed in like relations of precedency and contiguity to those objects, that resemble the latter'.<sup>80</sup> The cause is not any more conceived according to the model of a substance that acts: from Hume's perspective, something is a cause only relative to a given effect.<sup>81</sup> Hume's substitution of the concept of cause as the term of a relation to its conception as an active principle has exercised an enormous influence on the subsequent history of philosophical thinking about causation. In the tradition begun by Hume, causes are considered as *events* whose status as causes is only determined by their relation to other events, their effects. True, Hume calls causes 'objects' rather than 'events'. However, it has been argued<sup>82</sup> that the conception of causation as a relation leads naturally to conceiving the terms of this relation as events, i.e. as entities whose identity is essentially determined by their time of occurrence. One can reach that conclusion by the following reasoning. A causal process goes on at a particular time: if a stone breaks a window, it is true that, at first look, one will identify an object, the stone, as the cause of the window's breaking. But the logic of the relational conception of

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liaisons mutuelles propres à leur accomplissement, sans jamais pénétrer le mystère de leur production.'

<sup>80</sup> Hume, (1739), L.A. Selby-Bigge and P.H. Nidditch (eds), *A Treatise of Human Nature* (Oxford, 1955), p. 170; similarly p. 172). See also Hume (1748), 'An Enquiry Concerning Human Understanding' in L.A. Selby-Bigge and P.H. Nidditch (eds), *Enquiries Concerning Human Understanding and Concerning the Principles of Morals* (Oxford, 1975), p. 76.

<sup>81</sup> One could say that Hume takes up Boyle's above-mentioned thesis of the essential relational character of cause and effect – each being what it is only by virtue of its relation to the other – but gives it a new, non dispositional meaning. For Hume, the cause is not any more an active power and the effect is not any more a passive capacity; rather, both are events manifesting themselves as phenomena and bringing about ideas of sensation in subjects observing them.

<sup>82</sup> On the contemporary development of the conception of causes and effects as events, see D. Davidson, *Essays on Actions and Events* (Oxford, 1980) and T. Parsons, *Events in the Semantics of English* (Cambridge, 1990).

causation makes us look more closely: the effect is not the window, an object, but rather an event: the window's breaking. It is essential for a window's breaking that it occurs at a given moment; more generally, the conditions of identity of events necessarily contain a moment (or a stretch) of time. Once one looks at the situation from this perspective, it becomes clear that the stone is only in a direct causal relation to the breaking of the window at a precise moment: that which just precedes the breaking. It seems therefore inevitable to consider that strictly speaking it is not the stone as such that is the cause, but rather an event happening to the stone: the stone's flying with a given speed in a given direction at the moment preceding its impact on the window.

*Logical Empiricism and the Deductive-Nomological Model*

Logical empiricism (also called 'neopositivism') developed primarily by the philosophers of the Vienna Circle in the first decades of the 20th century is heir to both of these traditions: following Galileo and Comte, the logical empiricists' model of scientific explanation requires that such explanations be grounded on laws of nature. According to their 'deductive-nomological' model, which belongs to the heart of the doctrine of logical empiricism and whose classical formulation is due to Hempel and Oppenheim<sup>83</sup>, an explanation is a deductive argument whose premises (the *explanans* – that which explains) contain first a 'statements of antecedent conditions' (also called 'initial conditions') and second 'general laws'<sup>84</sup>, whereas the conclusion (the *explanandum* – that which is to be explained) contains a 'description of the empirical phenomenon to be explained' (*ibid.*). To explain scientifically is to show that a phenomenon or event is a logical consequence of the situation (described in the initial conditions) and the laws.<sup>85</sup> For Hume and his followers, any succession of events that happens regularly and satisfies the constraints of contiguity and succession is *ipso facto* causal, so that causation does not contain any 'thickness' (to use Simon Blackburn's expression) or obscurity going beyond the transparency of observable regularities. All explanations making use of laws (or 'nomological' explanations) are therefore causal explanations, without any implication that causes are something over and above the terms of observable regularities. Abstracting away from the regular relation that makes it a cause, a cause is simply an observable phenomenon. Leaving aside Hume's

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<sup>83</sup> C.G. Hempel and P. Oppenheim, 'Studies in the Logic of Explanation', in C.G. Hempel, *Aspects of Scientific Explanation and other Essays in the Philosophy of Science* (New York Free, 1965).

<sup>84</sup> *Ibid.*, p. 249.

<sup>85</sup> Strictly speaking, one should say that a certain *description* of the event to be explained is a logical consequence of a *linguistic expression* of the initial conditions and of the laws. However, insofar as there is no risk of misunderstanding, we shall nevertheless use the 'material mode' of speaking, instead of the 'formal mode', to use Carnap's terminology, for the sake of its greater simplicity and naturalness.

restrictions of succession and contiguity, the logical empiricists end up simply identifying nomological explanation with causal explanation. Carnap expresses this doctrine at a semantic level, as an analysis of the meaning of the word ‘cause’: ‘What is meant when it is said that event *B* is caused by event *A*? It is that there are certain laws in nature from which event *B* can be logically deduced when they are combined with the full description of event *A*’.<sup>86</sup> Popper, though in many respects critical of logical empiricism, also identifies causal explanation with deductive-nomological explanation as such: ‘To give a *causal explanation* of an event means to deduce a statement which describes it, using as premises of the deduction one or more *universal laws*, together with certain singular statements, the *initial conditions*’.<sup>87</sup>

*The logical Empiricist’s Suspicion about Dispositional Terms*

Logical empiricists insist above all on the importance of clarity in philosophy. In their writings, the traditional suspicion of obscurity with respect to dispositions takes the form of doubt as to whether the meaning of dispositional predicates is well determined. What exactly does it mean to attribute a disposition to an object? The background of such doubts about the completeness of the meaning of dispositional predicates is the verificationist theory of meaning. According to verificationism, the meaning of a predicate consists in its conditions of application, to be spelled out in observable vocabulary.

A predicate is categorical if those application conditions do not have a conditional form. ‘This cube is of sugar’ attributes to the sugar cube the categorical predicate ‘is of sugar’. ‘Is a square’ is another categorical predicate<sup>88</sup>: a surface is square if all of its sides are of equal length, where ‘... and ... are of equal length’ is itself a categorical predicate (with two places). However, ‘is soluble’ is not a categorical but rather a dispositional predicate, because the criterion of solubility has a *conditional* form: to say of something that it is soluble (in water) means that *if it was* put into water (in certain circumstances) *it would dissolve*. That this conditional character of the predicate, and thereby its dispositionality, belongs to

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<sup>86</sup> R. Carnap, *Philosophical Foundations of Physics* (New York, 1966), p. 194.

<sup>87</sup> K. Popper, *Logik der Forschung* (Tübingen, 1969), p. 31, trans. p. 59; italics Popper’s. This doctrine exists in many variations. Davidson argues for the equivalence between a particular causal relation and the existence of a general law allowing us to deduce a description of the effect from an appropriate description of the cause, in the context of our reasons to believe in the truth of particular causal statements: ‘It does not follow that we must be able to dredge up a law if we know a singular causal statement to be true; all that follows is that we know there must be a covering law. And very often, I think, our justification for accepting a singular causal statement is that we have reason to believe an appropriate causal law exists, though we do not know what it is’. D. Davidson, ‘Causal Relations’, in D. Davidson, *Essays on actions and events* (Oxford, 1980), p. 160.

<sup>88</sup> As we shall see later, not all philosophers agree that geometrical properties are exclusively categorical.

its meaning is shown by the fact that there is no categorical predicate having the same meaning as 'is water-soluble'.

What exactly is the alleged obscurity of such dispositional predicates, that justifies the logical empiricists' judgment that they should not be used in scientific explanations? Imagine hesitating to attribute the dispositional predicate 'is water-soluble' to a given object. If the object undergoes the appropriate test, in this case, if it is put into water, all is well, because in the circumstances of the test, the application conditions of the predicate are *not* conditional: while it undergoes the test, the object is water-soluble if it dissolves and not water-soluble if it does not dissolve. The problem arises in circumstances in which the object under consideration *does not undergo* any appropriate test. What determines in this case whether the object is water-soluble? In his seminal paper, *Testability and Meaning*<sup>89</sup>, Carnap replies that nothing does and that therefore the meaning of dispositional predicates is only partially determined.

The logical empiricists of the beginning of the 20<sup>th</sup> century thus seem to put forward a new argument against dispositions. To the traditional accusation of epistemic obscurity, they add that of semantic indeterminacy: the meaning of predicates attributing dispositions is only partially determined, and the indeterminacy concerns precisely those circumstances in which the need for dispositions is the most pressing: where they do not manifest themselves.

As a result, the conception of explanation in terms of nomic regularities promoted by the logical empiricists leaves no place for dispositions and causal powers. The predicates expressing lawful regularities must be categorical, for the simple reason that the meaning of the terms used in an explanation must at least be as clear as the meaning of the terms describing the phenomena to be explained. But descriptions of phenomena are always in categorical terms.

#### *Can Dispositional Predicates be Dispensed with? Goodman's Answer*

There are also new reasons to justify the use of dispositional terms. The most important is the observation that dispositional predicates are omnipresent not only in our everyday way of talking but also in scientific discourse: 'Besides the observable properties it exhibits and the actual processes it undergoes, a thing is full of threats and promises. The dispositions or capacities of a thing – its flexibility, its inflammability, its solubility – are no less important to us than its overt behaviour'.<sup>90</sup> To justify this thesis, Goodman explains that the dispositional

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<sup>89</sup> R. Carnap, 'Testability and Meaning' I, *Philosophy of Science*, 3 (1936): 419-471.

<sup>90</sup> N. Goodman, *Fact, Fiction, and Forecast* (Indianapolis 1973), p. 40. More recently, Rom Harré (R. Harré, 'Is There a Basic Ontology for the Physical Sciences?') and Nancy Cartwright have insisted on the central and ineliminable role of the reference to dispositions, capacities and powers in natural science. Here are the first sentences of Cartwright's book *Nature's Capacities and their Measurement*: 'Science is measurement; capacities can be measured; and science cannot be understood without them. These are the major three theses

character of a predicate is not always manifest in its morphology: many predicates whose morphology contains no explicit sign of dispositionality such as a suffix in ‘-able’ or ‘-ible’, have nevertheless a dispositional meaning. Goodman even holds that almost all predicates really have a dispositional meaning, the exception being predicates describing events, such as ‘bends’, ‘breaks’, or ‘burns’. However, most predicates attributing lasting properties are dispositional. ‘If a flexible object is one capable of bending under appropriate pressure, a hard object is one capable of resisting abrasion by most other objects. And for that matter, a red object is likewise one capable of certain color-appearances under certain lights.’<sup>91</sup> Even geometrical figure is attributed by a dispositional predicate, to the extent that the application condition of predicates expressing figure can be expressed in conditional form: such a predicate describes what one would find if an appropriate act of measurement was executed on the object: ‘a cubical object is one capable of fitting try squares and measuring instruments in certain ways.’<sup>92</sup>

Once the omnipresence of dispositional terms has been recognised, both in scientific and everyday discourse, one may take one of two attitudes, adopted respectively by Goodman and Quine. The point of departure for both is the conviction that Carnap has conclusively shown that no complete analysis of the meaning of such predicates can be given in the framework of first order predicate

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of this book.’ (N. Cartwright, *Nature’s Capacities and their Measurement* (Oxford, 1989), p. 1. She develops this thesis in her most recent book : *The Dappled World, A Study of the Boundaries of Science* (Cambridge, 1999).

<sup>91</sup> Goodman, *Fact, Fiction, and Forecast*, p. 40.

<sup>92</sup> *Ibid.*, Goodman’s thesis is controversial. Popper generalizes it even more than Goodman: ‘We can say that all physical (and psychological) properties are dispositional. That a surface is coloured red means that it has the disposition to reflect light of a certain wavelength. That a beam of light has a certain wavelength means that it is disposed to behave in a certain manner if surfaces of various colours, or prisms, or spectrographs, or slotted screens, etc., are put in its way.’ (K. Popper, ‘The propensity interpretation of the calculus of probability, and the quantum theory’, in S. Körner (ed.), *Observation and Interpretation* (London, 1957), p. 70). Shoemaker (1980), Mumford (1998) and Mellor (2000) show that the paradoxical conclusion that *all* properties are dispositional can be avoided by conceiving of this distinction as of a *semantic distinction between predicates*, rather than as an *ontological distinction between properties*: those predicates are dispositional whose meaning implies *analytically* (i.e. merely by virtue of the predicate’s meaning) that certain counterfactual conditionals are true of the objects to which the predicate applies. ‘X is fragile’ implies *analytically* that, if x was put into water, x would dissolve. Attributions of categorical predicates also imply such counterfactual conditionals, but in their case the implication is always *a posteriori*: its truth is not guaranteed by the mere meaning of the predicate, but rather by laws (known only *a posteriori*) applying to the property. S. Shoemaker (1980), ‘Causality and Properties’, repr. in S. Shoemaker, *Identity, Cause and Mind* (Cambridge, 1984), pp. 206-233. S. Mumford, *Dispositions* (Oxford, 1998). D.H. Mellor, ‘The Semantics and Ontology of Dispositions’, *Mind*, 109 (2000): 757-780. See the articles by Kistler and Mumford in this volume.

logic.<sup>93</sup> To the extent that one restricts the use of propositional connectors to negation, conjunction and disjunction, and material implication ( $\supset$ ), it is impossible to analyze the application conditions of a dispositional predicate in purely categorical terms, as far as objects not subject to any test for the disposition are concerned. In other words, one can only hope to find an analysis of the meaning of dispositional predicates if one uses a logical language stronger than standard first order logic. This is precisely the research tradition initiated by Goodman: his starting point is the observation that dispositions ‘strike us by comparison [with observable properties] as rather ethereal. And so we are moved to inquire whether we can bring them down to earth; whether, that is, we can explain disposition-terms without any reference to occult powers.’<sup>94</sup> According to Goodman’s hypothesis, which constitutes until today the framework for this debate, the meaning of dispositional predicates can be analyzed in categorical terms with the help of *counterfactual conditionals*: ‘Replacement of a statement like

*k* was flexible at time *t*

by a statement like

If *k* had been under suitable pressure at time *t*, then *k* would have bent,

has obvious promise as a step towards clarification’.<sup>95</sup> However, the semantics of counterfactual conditionals, which cannot be reduced to that of formulas of standard first order logic, itself raises some hard problems. The truth value of statements of counterfactual conditional form is not simply a function of the truth values of their antecedent and consequent propositions: they are not ‘truth-functional’ propositions. Since Goodman’s seminal essay, considerable progress has been made in the analysis of the semantics of counterfactual conditionals, and these advances have fuelled the research about the analysis of the meaning of dispositional predicates in those terms. However, the standard way to carry out this analysis uses the concept of possible worlds, the interpretation of which, notwithstanding its formal clarity, raises problems difficult enough for some to judge the whole project a failure.<sup>96</sup>

Counterfactual analysis in terms of possible worlds proceeds in this manner. An object that is not subject to any test for flexibility such as applying a force on it, is flexible in the actual world  $w_0$ , if and only if it bends without breaking in the nearest possible world in which it is subject to that test. In the context of the elucidation of the meaning of dispositional predicates, the most important problem this approach encounters is that of circularity. How do we know how a given object behaves in other possible worlds? Instead of having any independent grasp on the fact that the objects bends in a given non-actual possible world  $w_1$ , in which

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<sup>93</sup> First order predicate logic governs the usage of the quantifying expressions, or ‘quantifiers’, such as ‘all’, ‘some’ or ‘no’.

<sup>94</sup> N. Goodman, *Fact, Fiction, and Forecast*, p. 40.

<sup>95</sup> *Ibid.*, pp. 34-35.

<sup>96</sup> See Schmitz’ contribution to this volume.

it is subject to the testing force, the only ground we can have for judging that it bends in  $w_1$  is our judgment that it is flexible in the actual world  $w_0$ . It may turn out to be true in general that attributing to objects in other possible worlds manifest properties they do not possess in the actual world, is just another way of attributing it the property in a dispositional way, in the actual world. Goodman at any rate is convinced that the ‘problems of dispositions, counterfactuals, and possibles’<sup>97</sup> are inextricably bound up with each other, so that any analysis of one of them necessarily makes use of the others. This does not however prevent him from thinking that even if such analyses are inevitably circular because the analysis of each of these concepts uses the others, they may nevertheless be useful for clarifying the meaning of each.

...and Quine’s

Quine on the contrary holds that the only way to give a clear sense to dispositional predicates is to break out of the circle made up by the concepts of disposition, counterfactual, and the modal notions of possibility and necessity. Quine’s thesis is that the attribution of a dispositional predicate to an object reflects our incomplete knowledge of that object: when we call the sugar ‘soluble’, we in fact attribute a categorical property to it, though one that we know only incompletely. The real properties making true attributions of dispositions are categorical properties of ‘microstructure’.<sup>98</sup> By using a dispositional predicate, says Quine, ‘we can refer to a hypothetical state or mechanism that we do not yet understand’.<sup>99</sup> From his point of view, to attribute a disposition to an object is just a provisional way to characterize it *faute de mieux*, awaiting a more direct way. There are really no dispositional properties, the dispositional being only an incomplete and provisional way to characterize microstructural categorical properties. A disposition is but a ‘partially discerned physical property that will be more fully identified, we hope, as science progresses’.<sup>100</sup> This is also the position David Armstrong defends under the name ‘categoricalism’: according to this doctrine, what makes true the attribution to an object  $x$  of a dispositional predicate  $D$  is the possession by  $x$  of a *categorical* property. In Armstrong’s own words, ‘all true properties [...] are non-dispositional’.<sup>101</sup>

#### *The Contemporary Ontological Debate*

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<sup>97</sup> N. Goodman, *Fact, Fiction, and Forecast*, p. 33.

<sup>98</sup> W.V. Quine, *The Ways of Paradox and Other Essays* (Cambridge, 1976), p. 73.

<sup>99</sup> W.V. Quine, *The Roots of Reference* (LaSalle, 1971), p. 10.

<sup>100</sup> *Ibid.*, p. 13.

<sup>101</sup> D.M. Armstrong, *A World of States of Affairs* (Cambridge, 1997), p. 80; see also D.M. Armstrong, *A Materialist Theory of The Mind* (London, 1968), pp. 85-88.

At this point, the debate takes an ontological turn. For Quine's suspicion towards dispositional properties is really grounded in his scepticism about the idea of pure potentiality. Several authors have defended the thesis that only causally efficacious properties can be said to be real, and that causal efficacy of a property is equivalent to its being non-dispositional or categorical.<sup>102</sup> Against Shoemaker, who holds on the contrary that there is nothing in a property beyond the dispositions it lends its bearer, Armstrong argues in the following way: 'Every causal transaction, according to Shoemaker, is a matter of things with certain causal potentialities bringing about that these or other things have further potentialities, because properties are analyzed as nothing but potentialities. In Scholastic language, we never get beyond potency to act. Act, so far as it occurs, is just a shifting around of potencies. And is this a believable theory?'<sup>103</sup>

In the opposite camp, Shoemaker<sup>104</sup>, Molnar<sup>105</sup>, Lierse and Ellis<sup>106</sup> argue that the use of the causal criterion of reality according to which what is causally efficacious is real and what is real is causally efficacious, leads to the doctrine opposite to Quine's and Armstrong's categoricism: according to their 'dispositionalism', to conceive of a property as real means to consider that it is capable of acting causally and bring about effects. This dispositionalism does not deny that, e.g., the dispositional property of being soluble is grounded in the microscopic structure of the soluble substance. It only rejects the metaphysical thesis that those grounding properties are necessarily categorical. On the contrary, to the extent that they are real, and therefore causally efficacious, those grounding properties are themselves essentially dispositional: their identity is essentially determined by the effects they are capable of bringing about in different circumstances.

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<sup>102</sup> Cf. P.J. Holt, 'Causality and Our Conception of Matter', *Analysis*, 37 (1976): 20-29; H. Robinson, *Matter and Sense* (Cambridge, 1982); R. Swinburne, 'Reply to Shoemaker', in L.J. Cohen and M. Hesse (eds), *Aspects of Inductive Logic* (Oxford, 1983), pp. 313-320; D.M. Armstrong, 'The Causal Theory of Properties: Properties according to Shoemaker, Ellis and others', *Metaphysica*, 1 (2000): 5-20. See also Mumford's paper in this volume.

<sup>103</sup> D.M. Armstrong, 'The Causal Theory of Properties: Properties according to Shoemaker, Ellis and others' p. 14.

<sup>104</sup> S. Shoemaker, 'Causality and Properties'.

<sup>105</sup> G. Molnar, 'Are Dispositions Reducible?', *The Philosophical Quarterly*, 49 (1999): 1-17 and G. Molnar, S. Mumford (ed.), *Powers. A Study in Metaphysics* (Oxford, 2003)

<sup>106</sup> B.D. Ellis, and C. Lierse, 'Dispositional Essentialism', *Australasian Journal of Philosophy*, 72 (1994): 27-45; B.D. Ellis, 'Causal Powers and Laws of Nature', in H. Sankey (ed.), *Causation and Laws of Nature* (Dordrecht, 1999), pp. 19-34; B.D. Ellis, 'The New Essentialism and the Scientific Image of Mankind', *Epistemologia*, 23 (2000): 189-210; B.D. Ellis, *Scientific Essentialism* (Cambridge, 2001). See also M. Kistler, 'The Causal Criterion of Reality and the Necessity of Laws of Nature', *Metaphysica*, 3 (2002): 57-86. In this volume, Mumford and Kistler defend the thesis that there exist at least some dispositional properties lacking a categorical basis.

Mellor has offered a different defence of dispositions against the argument, put forward in particular by Quine, that the fact that their identity is determined by reference to possibilities sheds doubt on their reality. Mellor observes that such a link to the possible does not distinguish dispositional from categorical properties, because attributions of the latter imply just as well counterfactual conditionals, expressing how their bearers would behave in possible but non actual circumstances. Even a paradigmatic categorical property like that of being triangular appears as dispositional according to that criterion, because its attribution to an object implies the counterfactual conditional that 'if the corners were (correctly) counted the result would be three'.<sup>107</sup> Their link to non actual possibilities cannot be used to deny the reality of dispositional properties, on pains of paradoxically denying reality to all properties.

One might have expected that dispositions would have been rehabilitated automatically once it was recognized that verificationism, that extreme form of an empiricist theory of meaning, imposed too strong restrictions on the meaningfulness of expressions, in particular of theoretical terms. The predicate 'has a spin of  $\frac{1}{2}$ ' cannot be defined by means of a direct and unique test; but nevertheless physical theory, indirectly controlled by experimental tests, gives it a precise meaning. The conditions of attribution of dispositions appear to be neither more nor less problematic than the conditions of attribution of theoretical properties in general: the attribution of the property of having a spin of  $\frac{1}{2}$ , not being directly observable, necessarily presupposes accepting a theory giving it a well determined meaning and specifying the conditions (ultimately but indirectly observational) under which it is legitimate to attribute it to a given object. Attributing a disposition to an object that does not manifest itself seems to obey essentially the same logic: the property of being water-soluble cannot be attributed to a given dry sugar cube on the basis of a direct observational criterion. However, this does not imply at all that its attribution is arbitrary; it is simply based on indirect criteria, exactly in the same way as the attribution of theoretical properties. If one already knows that a given object is an electron, one may attribute it the property of having a spin of  $\frac{1}{2}$ , on the basis of the law that all electrons have this property. In the same way, it is enough to know that the cube in the sugar bowl is made of sugar to have a ground for attributing it the property of being soluble, by virtue of the lawful relation between the property of being of sugar and the property of being water-soluble.

However, dispositions remained suspect even after Quine and others had convinced the philosophical community that the distinction between theoretical and observational vocabulary is not sharp but rather a matter of degree, and that therefore there was no reason to think that the theoretical and the observational were two types of terms with radically different meaning and application conditions. The dismissal of this corollary of verificationism took away the major obstacle standing in the way of seeing that theoretical terms can have a definite

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<sup>107</sup> D. H. Mellor, 'In Defence of Dispositions', *Philosophical Review*, 83 (1974): 171.

meaning without being directly and explicitly definable in observational vocabulary.

However, the conditional nature of the meaning of dispositional predicates continued being a reason for doubting that that meaning was completely determined. To say of a substance that it is water-soluble, is not equivalent to saying what it is or what it does, but rather what it would be or what it would do were it subjected to certain tests. It cannot be denied that the conditional element in the meaning of dispositional predicates makes their attribution more problematic than the attribution of categorical predicates. However, the controversy about the status and origin of this special nature divides the accounts of dispositions presently defended in analytical metaphysics in two opposite camps. For those that may be called 'realists' about dispositions, the difference is only epistemological: dispositions themselves are real and complete, in the sense of having causal efficacy; only our *knowledge* of them is incomplete. For the 'anti-realists' in the opposite camp however, the incompleteness of the meaning of dispositional predicates is a sign of the fact that dispositional properties are not real properties at all. In this sense, Prior, Pargetter and Jackson, in a famous paper on dispositions<sup>108</sup>, argue that dispositions have no causal efficacy whatsoever and should therefore not be considered as real properties. What executes in their view the 'causal work' of making the sugar dissolve in the water, is not its solubility but rather a microscopic property underlying the disposition, called, as we have already seen above, the 'categorical basis' of the disposition. In the case of sugar, the basis may consist in a physico-chemical property of the sugar crystals. It is essential for the anti-realist position to conceive of dispositions as properties distinct from their basis.

The major drawback of anti-realism is that it makes dispositions causally inert. Thereby it goes against what many think to be central to our conception of ourselves as agents: according to the so-called causal theory of action, as defended in particular by Davidson<sup>109</sup>, our actions are not only motivated, justified, and 'rationalized' by our beliefs, desires and other mental states, but also causally brought about by them. This conviction is incompatible with anti-realism if those mental states are dispositional in nature. To get around this difficulty, Armstrong has proposed to make the hypothesis that mental dispositions are identical with their categorical bases. As the latter are no doubt causally efficacious, so are the mental dispositions identical with them. In the case of my mental disposition of knowing that Paris is the capital of France, Armstrong's hypothesis is that it is identical with a categorical property of my brain. On this count, he agrees with Quine that it is only our knowledge of dispositional properties that is provisional and incomplete, whereas the property itself is complete and causally efficacious.

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<sup>108</sup> E. Prior, R. Pargetter and F. Jackson, 'Three Theses about Dispositions', *American Philosophical Quarterly*, 19 (1982): 251-257.

<sup>109</sup> D. Davidson, 'Actions, Reasons, and Causes' in D. Davidson, *Essays on Actions and Events*.

Armstrong's 'identity theory' of dispositions can be made even stronger by supplementing it with the above-mentioned thesis held among others by Shoemaker<sup>110</sup>, Mumford<sup>111</sup> and Mellor<sup>112</sup>, that the distinction between the dispositional and the categorical is first of all a semantic distinction between two types of predicates, rather than an ontological distinction between types of properties. Just as individuals can be named with different proper names, such as 'Venus' and 'Phosphorus', so causally efficacious properties can be designated in two ways: either indirectly and conditionally by a dispositional predicate, or directly by a categorical predicate.

The papers collected in the first part of this volume bear testimony of the vivid debate about the nature of dispositions and causal powers in contemporary metaphysics. The main thesis common to all of them is that dispositions and causal powers are an essential and indispensable part of our conceptual scheme. In his paper, **Schmitz** shows in detail that Goodman's strategy of analyzing attributions of dispositional predicates in terms of *counterfactual* conditionals founders on essentially the same problems that Carnap has discovered for their analysis in terms of *material* conditionals. Evaluating the relevant counterfactual in cases in which an object is not subject to any test in the actual world already presupposes knowledge of whether it possesses the disposition; if the object is of a type whose members we know to possess the disposition because other objects of that type have been subjected to tests, we can attribute the disposition to it; however, as Carnap has pointed out, the attribution of dispositions to objects belonging to kinds none of whose members have been subjected to any tests is indeterminate; the contemplation of non-actual possible worlds does not provide any information allowing us to overcome this indetermination. What is worse, the analysis of dispositions in terms of counterfactual conditionals raises new problems: Schmitz shows that, under certain plausible conditions, dispositional predicates do not obey an essential condition of empirical meaningfulness, that the principle of Excluded Middle be an analytical truth. On the counterfactual analysis, it does not come out as analytically true that, for a given dispositional predicate P, for all objects x, either x satisfies P or it does not.

After these semantic arguments showing that dispositional predicates cannot be reduced to categorical predicates, even with the help of counterfactual conditionals, **Mumford** and **Tiercelin** argue on ontological grounds for considering dispositions as real properties in their own right. **Mumford** begins by setting out his 'ungrounded argument' for the thesis that there are ungrounded dispositions, i.e. dispositions that are not reducible to any categorical, and more basic, properties of their bearers. His main premises are that there are absolutely simple sub-atomic particles that have dispositional properties, and that the dispositions of an object

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<sup>110</sup> S. Shoemaker, 'Causality and Properties'.

<sup>111</sup> S. Mumford, *Dispositions* (Oxford, 1998).

<sup>112</sup> D.H. Mellor, 'The Semantics and Ontology of Dispositions', *Mind*, 109 (2000): 757-780.

can only be grounded on the properties of its constituents. The main part of his paper is dedicated to an analysis, and rebuttal, of the reasons for which the idea of an ungrounded disposition has been considered to be unacceptable within the Humean tradition. In this tradition, only categorical properties are considered to be able to provide truthmakers for attributions of predicates; in the absence of any such categorical properties, nothing ‘fills the space’ at which the possessor of the disposition is located, which is just a way of saying that ungrounded dispositions lack being, or reality. Mumford shows that neither Hume nor the prominent contemporary Humean, David Lewis, provide any strong reasons for denying that dispositions can ground other properties, nor for denying more generally that dispositions can be properties in their own right. On the contrary, Plato’s ‘causal criterion of reality’ according to which that which can affect other things causally is real (Mumford calls it ‘the Stranger’s test of reality’), pleads for considering dispositions as real, insofar as they are causal powers.

**Tiercelin** begins by rehearsing the main tenets of ‘dispositional essentialism’ (or ‘scientific essentialism’) as recently defended by Brian Ellis and others. First, natural kinds of events and processes constitute a metaphysically as fundamental category as natural kinds of objects or substances. Second, it is fundamentally its powers, i.e. what a thing is disposed to do, that makes it the kind of thing it is. Third, a thing’s causal powers, showing themselves in laws of interaction, are essential to it, which means that those laws are necessary, insofar as the kinds they hold of exist. In a second step, Tiercelin compares Ellis’s version of dispositional essentialism with Mumford’s. Mumford’s contribution is first of all to have clarified the semantic link between dispositional predicates and counterfactual conditionals: ascriptions of both categorical and dispositional predicates imply attributions of functional roles which in turn imply certain counterfactual conditionals. The difference is that the link between the predicate and the functional role is analytic in the case of dispositional predicates but a posteriori in the case of categorical predicates: in the case of the former but not the latter it is part of the predicate’s *meaning* that it corresponds to a functional role. Mumford shows that this implies that laws of nature have a derivative status with respect to dispositions, instead of being imposed ‘from outside’ on otherwise unconnected events, as the Humean tradition has it. Tiercelin argues that grounding laws on dispositions may solve the problem of exceptions (a thesis contested later in the volume by Schrenk): if ‘ravens are black’ attributes first of all a disposition to a natural kind, it may both explain why the disposition gives rise to a regularity and why it nevertheless allows for exceptions in which the disposition does not manifest itself, as it happens with albino ravens. But she also points out some difficulties for dispositional essentialism: once it is established that dispositional predicates cannot be reduced to conditionals, what is it that determines the objective essence of the disposition? She also shows the tension between Mumford’s dispositional essentialism and his thesis that the laws of nature are nevertheless contingent.

**Kistler's** paper is concerned with dispositional properties of macroscopic objects, such as fragility and solubility. He argues that such properties can be real in the sense of being causally efficacious without being identical to their microscopic base properties. This challenges a common presupposition of realists with respect to dispositions, such as Armstrong, for whom dispositional properties can contribute causally to their manifestations (which implies that they are real), and anti-realists, such as Jackson, Prior and Pargetter, according to whom dispositions are not themselves real (and thus not causally efficacious) because they are functional or second-order properties, whose first-order realizers are playing the causal role attributed by a dispositional predicate. Against the common idea that only microscopic base properties can be causally efficacious, Kistler argues that the criterion of causal efficacy is the existence of laws by virtue of which the property brings about other properties. Important laws of this type exist, e.g., for such cognitive dispositional properties as the representation of colour differences, which is why they can causally influence a subject's behaviour. On the way to this conclusion, Kistler refutes a number of traditional and influential arguments against the efficacy of dispositions and shows that the issue of the micro-reduction of a macroscopic disposition is independent of the question of its efficacy. Kistler's main thesis can be seen as complementary to Mumford's: Whereas Mumford argues for the existence of ungrounded dispositions, Kistler argues that macroscopic dispositions that may turn out to be reducible can be real and efficacious without being identical to their reduction basis.

The aim of **Michon's** paper is to defend causal powers against the traditional objection of vacuity. Undeniably, it is unilluminating to explain why smoking opium makes the smoker sleepy by making reference to opium's dormitive virtue. However, this does not show that the reference to opium's dormitive virtue is *never* explanatory. In some contexts it is, as when one asks for why smoking opium before driving a car enhances one's probability to have an accident. Michon analyzes the network of ontological, epistemological and logical presuppositions underlying the covering law account of causation, with its event ontology, and shows how these presuppositions make explanations in terms of causal powers inconceivable. He rehearses some arguments against the reduction of causality to lawful regularity: some causal relations appear to be unique and not to recur; not all laws are causal, whence the causal status of instances of the law cannot derive from their lawful status; the fact some event falls under a regularity does not by itself explain *why* it happens although it allows us to predict *that* it will happen. A genuine explanation requires reference to a mechanism underlying and responsible for the regularity. Michon develops a notion of natural action in which natural substances deploy their powers: such actions are the building blocks of the mechanisms whose discovery allows us to construct scientific explanations. Without powers, causal relations would appear capricious and remain incomprehensible. Michon joins Kistler in denying that powers are identical to the properties of what he calls (following Kenny) their 'vehicles' and Mumford in thinking that nothing stands in the way of the possibility of ungrounded powers.

Michon introduces an important distinction between active tendencies and passive potentialities, the former having their ground within the (natural) agent, the latter being relative to powers external to it. Potentialities alone are incapable of making anything happen; however, tendencies or active powers can. This distinction provides the means for refuting an important objection against the dispositionalist ontology (put forward by Armstrong<sup>113</sup>): confusing tendencies with potentialities, the objection says that if all basic properties were dispositional, nothing would ever happen *actually* because all changes would remain forever *potential*. A natural agent acts necessarily in accordance with its active powers.

**Gnassounou**'s paper is concerned with what he calls "conditional possibilities", for which the assertion or denial of a modality is dependent on a specific condition, such as: "*if* the water is heated, it *can* boil" and "*if* the water is not heated, it *cannot* boil". He evaluates the pros and cons of an argument put forward by Lehrer and polished by Anscombe, relying on the use of such conditional possibilities, against any attempt to reduce the ascription of a possibility to a conditional in which no modal word occurs. Taking up the distinction established by Michon between two kinds of modalities, the general power of an agent (a disposition) and the circumstantial possibility of the power's exercise, he confirms that the conditional analysis of the disposition is not redeemed nor invalidated by Lehrer's argument, whereas the circumstantial possibility turns indeed out not to be reducible to a conditional.

**Jansen** argues that, although dispositions can be attributed to entities of all four fundamental Aristotelian ontological categories, their attribution to individual substances is most fundamental, on three counts: metaphysically, logically and epistemically. He establishes metaphysical priority by showing that attributions of dispositions to universal kinds of substances, to property tokens (tropes) and to universal property types cannot be true without the corresponding attribution of the disposition to an individual substance being true. He establishes logical priority by analysing the logical form of disposition attributions to entities of the former three categories, showing that these forms all contain attributions to individual substances as an element. Finally, as to epistemic priority, he shows that we can know a lot about the dispositions of individuals without knowing anything about the dispositions of the kinds they belong to or of their properties, but that we can only obtain knowledge about the latter by gaining knowledge about the former. Thus, while agreeing with Gnassounou that individual substances are the fundamental bearers of dispositions, Jansen disagrees with him in arguing that they can also meaningfully be attributed to entities of the other three categories. Jansen shows that the attribution of dispositions (at least of what he calls 'sure-fire' dispositions and contrasts with probabilistic dispositions) presupposes a 'principle of manifestation' and a 'principle of enabling'. According to the former, the presence of a disposition to M-in-circumstances-C, in a situation of type C, leads to

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<sup>113</sup> D. Armstrong, 'The Causal Theory of Properties: Properties according to Shoemaker, Ellis and others'.

manifestation M. According to the latter, if an object displays M in circumstances C, it must have had the disposition to M-in-circumstances-C. The basic logical form of a disposition attribution is 'x has the disposition to M-in-circumstances-C', or '(dyn (M.C)) (x)'. But Jansen argues that we usually ascribe whole families of such dispositions, attributing to an object specific manifestations for a whole range of circumstances. This is compatible with all these attributions having a single property as their truthmaker.

### **Dispositions in Contemporary Philosophy of Science**

Metaphysics is not the only philosophical discipline in which the interest for dispositions has grown. In fact we have already seen that philosophy of science has discovered its own new reasons for thinking that the notions of disposition and causal power are essential for scientific discourse. This is the main theme of the papers in the second part of this volume.

One important topic in philosophy of science that has profited from the rediscovery of dispositions is the analysis of the role of idealization, itself indispensable for the discovery of laws of nature. As we have said before, the modern conception of scientific explanation tries to avoid postulating causes in the sense of substantial powers, mainly because such powers are thought to be inaccessible to scientific experiments. Modern science has habitually been thought to have substituted the search for regularities among phenomena to the search for causes. Scientific explanation is thought to consist in the integration of the phenomena to be explained within a regularity. However, those regularities that are lawful are in general not directly accessible to observation. To take a simple example, according to Galileo's law of free fall, all bodies undergo the same acceleration if they are in free fall near the surface of the earth. However, the observation of real bodies falling in real circumstances never shows such a uniform acceleration. Common sense is surprised to learn this law, because what observation rather teaches us is that feathers fall more slowly than stones. In fact, the law of free fall only applies to bodies that are not subject to any other force than the gravitational attraction exercised by the earth, which is never the case in real circumstances. One can therefore only abstract that law from observation by abstracting away all other factors influencing the speed of a real body's fall, such as the force exercised on the body by friction with the air. The law can only be obtained by 'idealization', by conceiving a phenomenon taking place in hypothetical circumstances in which it is determined by a single factor (or a small number of factors), instead of being determined by the large number of factors present in every real situation. Without constructing such simplified hypothetical situations, the law could not possibly have been discovered. (This point is taken up in particular by Hüttemann's paper in this volume). This simplification is fully justified by the possibility of getting back to real and complex situations in a second step: the properties of real falls are explained by conceiving them as the result of the superposition of the effects of all

factors present in the situation, each obeying to its own laws. Taken in isolation, each of these laws does not correspond to any real regularity but to hypothetical regularities existing in hypothetical ideal circumstances. At this point, several authors have suggested that laws of nature do not directly bear on concrete objects, i.e. objects having many properties subject to any influences, but rather bear on their *dispositions*.<sup>114</sup> One can fruitfully use the law of free fall to predict the properties of the falls of real objects although none of these falls directly obeys that law, by making the hypothesis that real bodies nevertheless have the disposition to fall freely in accordance with that law.

The concept of disposition also provides a justification for our usage of the concept of causation in Hume's sense of an instance of a regularity. In a famous paper, Russell<sup>115</sup> has observed that everyday events that we explain causally are in general so complex that they cannot give rise to any regularity. If, following Hume, one assumes that one event causes another event because regularly, events of the first type are followed by (contiguous) events of the second type, one must face the fact that everyday events never get repeated: no two car accidents exactly resemble each other in every respect. As Russell explains, the notion of exact resemblance only applies to the measurable quantities described by the quantitative laws of physics. However, he points out, it is conceptually impossible to consider the relation of these laws as causes and effects: physical laws relate simple properties not complex events. Furthermore, they do not bear on events taking place at different places and times, whereas causes always have spatiotemporal locations different from their effects. The differential equations of physics<sup>116</sup> rather express functional dependencies of different properties an object possesses at a given moment. From this, Russell concludes that everyday causal judgments cannot be justified by laws of nature, which is the central hypothesis of the nomological account of causation mentioned above. The form of the laws of contemporary physics makes it impossible to use Hume's concept of causation in terms of (lawful) regularity to characterize the relations between everyday macroscopic events, such as car accidents. However, once the properties of a complex object are conceived of in terms of the causal powers they give their bearers, it becomes possible to understand the evolution of the object as resulting from the superposition of the

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<sup>114</sup> See N. Cartwright, *How the Laws of Physics Lie* (Oxford, 1983). N. Cartwright, *Nature's Capacities and their Measurement* (Oxford, 1989). N. Cartwright, *The Dappled World, A Study of the Boundaries of Science* (Cambridge, 1999). P. Lipton, 'All Else Being Equal', *Philosophy*, 74 (1999): 155-168. M. Kistler, 'Laws of Nature, Exceptions and Tropes', *Philosophia scientiae*, 7 (2003): 189-219.

<sup>115</sup> B.A.W. Russell, 'On the Notion of a Cause', repr. in B.A.W. Russell, *Mysticism and Logic* (London, 1986).

<sup>116</sup> Laws that have the form of differential equations express the dependency of the state of a physical system on the state preceding it by an infinitesimal time interval. The concept of such laws has been made accessible by the invention of the differential and integral calculus by Newton and Leibniz, which allows their expression in the form of differential equations.

effects of many causal powers exercised by each of its properties in the circumstances. In the first part of the volume, several authors (in particular Mumford, Kistler, Michon and Gnassounou), show how realism about powers and dispositions provides the starting point for a non-Humean conception of causation. In his paper, **Harré** develops his thesis that the aim of science is to provide explanations of observed regularities by postulating powers that are not directly observable. He argues that powers allow us to account for the existence of exceptions to laws of nature, whereas no sense can be made of the notion of an exception within the Humean analysis of laws as universal regularities. (Schrenk, later in the volume, challenges the thesis, which Harré shares with Tiercelin, that powers allow us to make progress with the problem of exceptions.) According to Harré, natural kinds are just clusters of dispositions and powers. But he shows that the attribution of powers to particulars cannot be analysed without making reference to the ‘intrinsic nature’ of the particular, without making use of the ‘*ceteris paribus* clause’, and without making use of a conditional expression that can be satisfactorily analyzed neither in standard first-order logic nor modal logic. (This was the main conclusion of Schmitz’ paper.) Taking up Michon’s and Gnassounou’s distinction between active powers and passive ‘liabilities’, Harré argues that there is a whole family of dispositional concepts, resembling each other on various counts, but not being susceptible of any common analysis. In line with the analysis put forward earlier in this introduction, Harré distinguishes between two traditions of physical explanation. A conservative tradition postulates, as the unobservable ground of observable phenomena, other and just smaller entities of the same kind. Such ‘iconic model building’ restricts its explanatory resources to concepts taken from the domain of observable phenomena. For the other more ‘radical’ tradition, represented by Gilbert, Boscovich, Kant, Faraday and Bohr, the scientific explanation of observable phenomena must proceed by postulating powers, in particular fields, which are entities of a radically heterogeneous type with respect to observables. Harré joins Mumford and Michon in pointing out that the postulate of irreducible (or ‘original’, as Harré calls them) powers is the price to pay for genuine scientific explanations.

**Cartwright** agrees with Harré that there is a whole family of disposition concepts admitting of no common analysis. The main contribution of her paper is a careful distinction between two concepts of this family: dispositions and powers on one hand and capacities on the other. Here are some distinguishing features on her list: Powers or dispositions are not always displayed, whereas some capacities are. Powers but not capacities are basically ascribed to substances (Cf. Jansen, Michon, and Gnassounou). Dispositions are characterized by a limited number of conditionals, linking them to characteristic manifestation in certain test conditions. By contrast, the list of manifestations of a capacity is open-ended; hence there is no set of conditionals defining the essence of a capacity. What Cartwright argues is the most important criterion for distinguishing dispositions from capacities is what she calls ‘malleability’: Dispositions can be interfered with (earlier in this introduction we have mentioned ‘antidotes’, which rob dispositions of their typical

manifestations), triggered and enhanced or diminished. Concerning triggering, enhancing and diminishing, she distinguishes fundamental physical capacities, such as the gravitational capacity, that need no triggering and cannot be enhanced or diminished, and derivative capacities, e.g. of economic systems, that can be triggered, as well as enhanced and diminished. This makes economic capacities more resemble dispositions than fundamental physical capacities do. Behind the possibility to be interfered with stands the most common feature of dispositions and capacities, their ‘two-sidedness’: Both dispositions and capacities are conceived in relation and opposition to their manifestations. This is what groups them together into one family distinct from the family of categorical properties. Finally, Cartwright joins Harré in concluding that both capacities and dispositions are an essential part of the conceptual apparatus of science.

**Hüttemann** starts from observing that many physical laws describe the behaviour of objects in circumstances that may never be actually realized. How we can come to know such laws, and how laws bearing on ideal circumstances can nevertheless contribute to scientific explanations of what happens in non-ideal situations is a much discussed problem in philosophy of science. One traditional worry is that such laws can only be expressed by statements with *ceteris paribus* clauses, and that the essential indeterminacy of such clauses makes it impossible to confirm or refute *ceteris paribus*-law statements, which means that they do not have any definite meaning at all. Hüttemann argues that this problem can be solved by supposing that laws bear on dispositions, which are something that carries over from ideal to real (non-ideal) circumstances. However, as he points out, the epistemic transition between the ideal and the non-ideal presupposes that the disposition exhibits some kind of continuity between these kinds of circumstances. More precisely, only ‘continuously manifestable dispositions’ (or ‘CMDs’) can play a role in scientific explanations. It is only to the extent that a disposition is ‘continuously manifestable’ that we can infer a system’s real behaviour from its behaviour in ideal circumstances; conversely, only the supposition that a disposition is a CMD gives us epistemic access to the behaviour of systems in ideal circumstances, on the basis of the observation of their manifest evolution in non-ideal situations. Hüttemann joins the other authors of this volume in holding that the only way to make sense of modern science since Galileo is the hypothesis that dispositions are the fundamental object of scientific enquiry. In the second part of his paper, Hüttemann develops a new account of the relevance of dispositions for the analysis of causation. He agrees with other authors of this volume (in particular, Michon and Gnassounou) that dispositions are not to be construed as causes of their manifestations. He rather suggests that laws establishing connections between dispositions can serve as truthmakers for counterfactual conditionals, which can then be used, following David Lewis, to analyse the causal relation between events.

**Schrenk**’s paper challenges the thesis shared by several authors of the volume (in particular, Tiercelin, Michon, Harré and Hüttemann) that the hypothesis that laws bear on dispositions rather than manifest or ‘categorical’ properties allows us to

make sense of exceptions, and to give a definite meaning to law statements containing *ceteris paribus* clauses. He first reviews some of the well-known difficulties for *ceteris paribus* law statements: they seem to be empirically vacuous or tautologous, they cannot be confirmed or refuted and they cannot support counterfactual conditionals. Schrenk then analyses carefully Cartwright's version of the thesis that laws determine capacities. He discovers an important ambiguity in her writings: taking the example of the Coulomb force law, sometimes Cartwright considers the electrostatic force as a disposition, which is always present between electrically charged bodies at a given distance; but sometimes she treats the force as the *manifestation* of a disposition, which means that the force is *not* always present: whenever it is interfered with, it is not. More importantly, Schrenk argues that, even when the former reading is chosen, the thesis that the law attributes a capacity to electrically charged bodies does nothing to solve the problems raised by *ceteris paribus* clauses. His reason for this claim is that the relation between dispositions and their manifestations is plagued by exactly the same problems as the relation between laws bearing on the behaviour of systems in ideal circumstances and their consequences on real situations. As extensively shown in this introduction and other contributions to this volume, interferences and 'antidotes' make it impossible to state explicitly and generally how a system with a given disposition will behave in arbitrary circumstances. Hence, the thesis that laws ascribe dispositions does nothing to help us understand why we are able to test them in non-ideal circumstances and why we can use them in counterfactual reasoning.

Dorato and Barberousse's contributions make the case for the fundamental and irreducible status of dispositions in science stronger by looking closely at two important types of dispositional properties, the superposed states of quantum systems (Dorato) and specific heats (Barberousse). **Dorato** shows that, on the most important interpretations of quantum mechanics, the properties of quantum systems corresponding to observables for which the system is not in an 'eigenstate' (in other words, with respect to which it occupies a superposed state) are dispositional. Furthermore, on almost all interpretations (the exception being Bohm's interpretation in terms of 'hidden variables') such dispositional properties of quantum systems before their measurement are irreducible, i.e. cannot be reduced to categorical properties of the system. This conclusion is mainly justified by the fact that the properties that can be attributed to quantum systems which are in superposed states with respect to a given observable, are *contextual* in a strong sense of the word: it is only through the interaction with a measuring device that they give rise to a categorical, measured value of the observable, where the obtained value depends also on the measuring device. Hence, before measurement, definite values of the observable can be ascribed to the system only as the set of dispositions to give rise to those definite values as a result of certain measuring interactions. In Bohr's (so called 'Copenhagen') interpretation, these dispositions are considered as fundamental, i.e. not reducible to any intrinsic categorical properties of the system. Dorato shows that the same is true of almost all other

important interpretations of quantum mechanics: Rovelli's 'non-collapse' view, many-worlds and many-minds interpretations, and 'spontaneous collapse' theories, as proposed by Ghirardi, Rimini and Weber. Only David Bohm's interpretation leads to a different result in this respect: in Bohm's 'hidden variable' interpretation, a quantum particle's *position* is considered to have a definite (though 'hidden') value independent of measurements. However, position is the only observable whose value for a given system is not strongly contextual and can therefore be considered as categorical. All other variables, such as that of the spin of a particle in a given direction, are strongly contextual and therefore dispositional in the same sense as in the Copenhagen interpretation, the difference being that these dispositions are considered to be reducible to position and the context of measurement.

If Dorato's analysis of the properties of quantum mechanical systems shows that science supports Mumford's thesis that there are ungrounded irreducible dispositions, **Barberousse's** analysis of specific heats shows, in agreement with Kistler's thesis about macroscopic dispositions, that science gives credit to the idea that macroscopic dispositional properties are real and causally powerful. Specific heats are measurable properties of macroscopic systems whose identity conditions are determined by the theoretical context of macroscopic thermodynamics, linking specific heats with other thermodynamic properties, such as entropy, heat, or (a gas's) compressibility. Historically, the reductive explanation of the specific heats of gases had to wait for the development of the quantum mechanical description of the gas molecules. In the last part of her paper, Barberousse develops a subtle analysis of the relation of the heat capacity of a gas to its microscopic basis, i.e. the categorical properties of its constituent molecules. She shows that some influential arguments (due to D.H. Mellor) against the identification of the macroscopic heat capacity of a gas with microscopic properties of its constituents are not conclusive. Her own thesis is that the reduction of the specific heat of a gas to the microscopic properties of its constituent molecules rests upon irreducibly statistical properties, expressed in terms of infinite 'ensembles'. It follows that such a thermodynamical dispositional property as the specific heat of a gas cannot be identified with any categorical (or 'occurrent') property of its microscopic constituents.