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INTRODUCTION

INTRODUCTION

I.
CETERIS PARIBUS LAWS

An alleged law of nature—like Newton's law of gravitation—is said to be a *ceteris paribus* law if it does not hold under certain circumstances but only ‘when other things are equal’. Typical examples are: ‘provided the supply remains constant, the price of a product increases with growing demand, *ceteris paribus*’, ‘all bodies fall with the same speed, *ceteris paribus'*, ‘haemoglobin binds O_2, *ceteris paribus*’.

There is, however, an inherent tension in the notion of a *ceteris paribus* law: on the one hand, laws are said to be strict universal regularities, on the other hand, the proviso clause seems to allow for certain exceptions.

Moreover, in the current debate on *ceteris paribus* laws fervent opponents to the whole idea of law statements with proviso clauses point out that no good sense can be made of a statement like ‘All Fs are Gs, *ceteris paribus*’. Such a phrase, so they say, is either tautologous like ‘All Fs are Gs, unless not’ or it stands for a proposition like ‘All Fs which are also… are Gs’ the gap of which we are unable to close.

Many of those who argue in favour of the idea of *ceteris paribus* laws, however, not only claim that a proper analysis of what the proviso clause is supposed to mean can be given but even that *all* laws are of *ceteris paribus* character.

The strong latter statement sounds somehow acceptable when restricted to the special sciences. When it is related to fundamental laws, it causes sceptical responses. That the laws of biology or psychology are open to exceptions finds more support than the view that laws of physics do not always hold. Yet, some philosophers defend even the radical view that the basic laws of physics are *ceteris paribus* laws.

Combining the two issues—proviso clauses in law statements and the status of special sciences—we find, hence, three major positions:

(i) On one side of the spectrum we face a strong scepticism: contrary to fundamental laws which are exceptionless the *alleged* laws of the special sciences are, in fact, hedged with provisos and as such do not really count as laws. At best, they are handy *rules* which allow some sort of explanation and prediction. Consequently, no account of *ceteris paribus* laws is necessary for everything which bears such a proviso is immediately disqualified as a law. This view can *either* (i.i) be combined with a radical position concerning the special sciences which claims that they are immature *or* (i.ii) with the friendlier view that they are grown-up theories that do not need any laws because their theoretical significance is based not on the formulation of strict statements but on a different means of explanation.[1] The first, hostile approach, might be accompanied by the optimistic view (i.i+) that the undeveloped special sciences will advance and eventually formulate strict laws or it might pessimistically consider (i.i-) that these sciences will wither and will be reduced to the physical sciences. In any case, all shades of position (i) share a negative view when it comes to the possibility of *ceteris paribus* laws.

(ii) Less radical is a position which still believes that fundamental laws are strict but which differs in that it accepts the law status of the special sciences' *ceteris paribus* laws. This view has faith in the possibility of a proper account of how the proviso clauses are supposed to work.[2]

(iii) The extreme on the other side of the spectrum, i.e., the mirror image of position (i), claims that there are *ceteris paribus* laws all the way

---

[1] These are, for example, explanations of a causal but not lawlike type or of statistical character (cf. (Earman & Roberts 1999: 467ff), (Earman, Roberts & Smith 2002), (Woodward 2002)).

[2] For example: (Pietroski & Rey 1995), (Fodor 1991). Some of the philosophers who give accounts of how non-fundamental *ceteris paribus* laws are to be interpreted also claim that even the fundamental laws are prone to *ceteris paribus* clauses. One might, therefore, rather list them under (iii). Yet, later I will show that their beliefs regarding fundamental laws are most probably grounded in faulty assumptions.

down to the physical sciences. Proponents of this position try to offer theories of how to interpret proviso clauses for all kinds of laws, not only those from chemistry, biology, psychology, etc. but also from fundamental physics:

> *Ceteris paribus* clauses surely do plague the social sciences. That, however, does not separate them from the natural sciences, for *ceteris paribus* clauses are endemic even in our best physics. (Kincaid 1996: 64).
>
> All laws are *ceteris paribus* laws. (Footnote: I even intend to include most so-called fundamental laws of physics.) (Cartwright 1995: 155)
>
> Whatever the law says *must* happen, hold or obtain, everything else being equal. (Harré 1993: 79)
>
> Given current science, the appropriate question would seem to be whether *any* laws are strict. (Pietroski and Rey 1995: 88)
>
> The *ceteris paribus* clause is often tacitly employed even in highly developed branches of physics. (Nagel 1961: 560; fn. 8)

The striking intrinsic tension within the notion of a *ceteris paribus* law is, again, this: general theories of lawhood emphasise that laws, whatever else they are, must be universal regularities. Yet, a proviso clause attached to a law statement suggests that in certain unfavourable circumstances exceptions to the law are acceptable. Advocates of (ii) and (iii) alike have to tell us how this contradiction can be resolved. Moreover, they have to tell us how some more specific problems the *ceteris paribus* clause raises can be answered (see below). Proponents of (i) are off the hook. Yet, they, too, have to give us some incentive to believe what they believe: that fundamental laws are really strict.

In the next sections I discuss some concrete difficulties an advocate of *ceteris paribus* clauses has to face. Then, I introduce strategies how to meet these challenges. The central question of my book will emerge from these discussions. Its theme will differ from the usual questions asked about *ceteris paribus* laws but I will motivate this deviation. An outline of the subsequent chapters will conclude this introduction.

II. DIFFICULTIES WITH *CETERIS PARIBUS* LAWS

The *ceteris paribus* clause in law statements is highly problematic. Amongst the more infamous difficulties are the following (I have already mentioned some of these above):

(i) 'All Fs are Gs, *ceteris paribus*', is in danger of being tautologous or incomplete: tautologous if we specify or define the *ceteris paribus* clause by saying 'All Fs are Gs, except in those cases where Fs are not Gs'; incomplete if the *ceteris paribus* clause is thought to stand for an exclusion clause (in the antecedent of the law) of possible interferences A, B, C, etc. The problem with this variant is that we most certainly do have to leave a gap in our statement 'All Fs are Gs, unless A interferes, or B interferes, or, …' for the reason that we do not know all the interferers; not least because there might be endlessly many.

One might want to try to formulate an exclusion clause in general terms instead which covers all interferers and exceptional circumstances together. This attempt, however, has to face the difficulty that the unfavourable circumstances might well be too heterogeneous to allow for a general description other than that the law does not hold in those circumstances. Yet, the latter description leads us back to the tautologous statement from above.

Apart from these severe problems, a minor hurdle might be that the circumstances to be excluded might not fall within the scope of the science of the law in question. In 'Birds can fly, unless they are struck by lightning', the weather conditions are not a biological phenomenon.

To summarise, tautologous statements are empirically not very useful, since they are empirically vacuous; incomplete statements, on the other hand, fail to express a determinate content.

(ii) Apart from these semantic problems for *ceteris paribus* law statements, we face other, epistemic, difficulties: predictions might fail since *ceteris paribus* laws do not hold good in every situation. Also, proviso laws cannot be refuted easily for the *ceteris paribus* clause could be misused as an immunisation strategy: we could claim that whenever the law does not hold the *cetera* weren't *paria*, a bad result for the sciences if we are keen on demarcation. A non-falsifiable empirical science is in danger of resembling a pseudo-science like astrology.

Note also that the confirmation of a *ceteris paribus* law aggravates the difficulty posed by the Duhem-Quine thesis, that any (alleged) empirical statement cannot be individually confirmed or refuted but rather faces the tribunal of experience together with a whole bunch of auxiliary assumptions. The additional problem is that the deduction of an observational sentence from a law is subject to probably unspecified provisos, that is, the additional assumptions are unknown (cf. Hempel 1988: 25).

(iii) Finally, *ceteris paribus* laws do not support counterfactuals as straightforwardly as strict laws do since we have to postulate that, in counterfactual circumstances, the unknown *cetera* are *paria*.

III.
VERBAL ISSUES

Before I turn to suggestions of how to deal with the problems mentioned above some linguistic remarks are in order. Quite clearly, the term '*ceteris paribus* law' is, although well established and often used in the literature, a misnomer. Meaning literally *all else being equal*, '*ceteris paribus*' is a relational term and suggests, vaguely, that unless some things, for example a particular set of actual circumstances, are equal to other things, for example an ideal set of circumstances, the law does not hold.

However, philosophers often do not mean anything like this. Rather *ceteris paribus* might stand for any of the following phrases: under normal or ideal circumstances, provided unfortunate events do not happen, provided nothing interferes. Or, minimally, it might stand for 'but there are exceptions'. Needless to say, most of these interpretations are far from being correct translations of the original Latin phrase.[3] Indeed, one should use a neutral term like ‘proviso law’ instead of ‘*ceteris paribus* law’ if one intends to cover all these different readings. However, here I will adopt the general practice and use ‘*ceteris paribus*’ and ‘proviso’ interchangeably. The minimal interpretation ‘there are exceptions’ is the intended meaning.

IV.
THEORIES OF *CETERIS PARIBUS* LAWS

No matter which reading we choose we are confronted with difficulties. Theories trying to solve them are as diverse and numerous as the possible interpretations of the *ceteris paribus* clause. In what follows I will introduce the ideas behind some important approaches. I do not intend to criticise or evaluate them, since this has already been done in the ever growing literature on *ceteris paribus* laws; not least in a special volume of *Erkenntnis* in 2002 (Earman, Glymour & Mitchell 2002). Rather, I aim to show that while philosophers have concentrated on semantic and epistemic issues associated with *ceteris paribus* laws they have somewhat neglected interesting related metaphysical questions. It is on the metaphysics of *ceteris paribus* laws that this book will concentrate. The specific question I will ask will emerge from the subsequent sections.

Epistemology and Pragmatics. A large class of accounts of *ceteris paribus* laws extracts its core ideas from scientific practice. Marc Lange, for example, claims that a *ceteris paribus* clause reflects or hides tacit

---

[3] Joseph Persky claims in a historical article that “*ceteris paribus* was not a common expression in Latin literature. For example, it appears nowhere in the works of Cicero. […] Its use in anything like its current meaning comes with the scholastic schoolmen and their Latin disputations. The earliest confirmed use I could find was in 1311.” In a footnote he adds: “The expression was not used in the voluminous works of Thomas Aquinas (1225-1274), so the 14th century seems a likely time of origin” (Persky 1990: 188).
Excellent classifications of the different meanings of the *ceteris paribus* clause can be found in the works of Gerhard Schurz and Geert Keil: (cf. Schurz 1999), (cf. Keil 2000: 227).

knowledge possessed by researchers: during their training, researchers learn to distinguish disturbances or abnormal circumstances from falsifications of the law. However, this *know-how* cannot be made explicit. Lange compares this issue to Wittgensteinian rule following. In fact, laws, on his account, simply *are* rules—namely rules for making predictions. Yet, just as there cannot be a rule as to how to apply a rule, there cannot be explicit statements laying bare the criteria for correct applications of the laws:

> It is futile to try to avoid this by including in the rule an expression that specifies explicitly how to apply the rest of the rule, for alternative interpretations of that expression are likewise conceivable. In the same way, a law-statement specifies a determinate relation only by exploiting implicit background understanding of what it would take for nature to obey this law. This point applies to *any* law-statement, whether or not it *blatantly* appeals to implicit background understanding by referring to "disturbing factors". (Lange 1993: 241)

For my later purposes, it is important to note that Lange's view has a clearly instrumentalist and anti-realist flavour when it comes to the ontological status of laws.[4]

Similar (though not openly anti-realist) is an interpretation by Pietroski and Rey who, also, treat the *ceteris paribus* issue on epistemic grounds. A proviso clause is, in their eyes, a promise to the effect that if the *application* of a *ceteris paribus* law should fail a scientific explanation can be given of what went wrong. The advantage of this account is that failures only have to be explained with hindsight, i.e., the *ceteris paribus* clause does not have to be replaced by an exclusion list of interferers or by a list of what counts as ideal or normal circumstances *before* the law is applied. "The details […] need not be *spelt out*: there is an *existential quantification over* interfering factors, not a citation of the factors themselves" (Pietroski 2000: 127).

Again, the status or character of laws is shifted towards the epistemic end: laws are primarily treated as tools for predictions and explanations. Pietroski explicitly writes:

[4] For a critique of Lange's view see (Earman and Roberts 1999: 450).

> I think the notion of explanation is, at least pretheoretically, clearer than that of cp law. So one can use the notion of explanation to help resolve the puzzles surrounding cp laws. (Pietroski 2000: 123)

Admittedly, both Lange's and Pietroski and Rey's account seem to solve at least one of the riddles I have introduced above: *ceteris paribus* law statements are, on their interpretation, neither tautologies nor empty statements because the *ceteris paribus* clause is either moved into the realm of knowing-how or it is spelled out just in case things go wrong.

Non-Monotonic Reasoning. Epistemic accounts like these culminate in attempts to dissolve *ceteris paribus* laws into non-monotonic reasoning. A *ceteris paribus* law is one premise in a non-truth-preserving but plausible or probable inference: if 'Fa', and: 'Fs are Gs, *ceteris paribus*', then, *likely* or *plausibly*: 'Ga'. Proponents of these accounts are Wolfgang Spohn (Spohn 2002), Wolfgang Schurz (Schurz 1999: 224-5, Schurz 2001: 369), and Arnold Silverberg (Silverberg 1996: 210ff). Moreover, some philosophers who are sympathetic to epistemic accounts, like Glymour, even introduce subjective and pragmatic elements: "I suggest that *ceteris paribus* claims have a kind of formal pragmatics." (Glymour 2002: 395)

Truth-conditions and Semantics. There are also truth-conditional and/or semantic accounts.[5] Silverberg, for example, applies possible world semantics to state truth-conditions for *ceteris paribus* laws. His claim is, roughly, '*ceteris paribus*: if A then B' is true *iff* B is true in all possible A-worlds that are appropriately ideal and that are otherwise most similar to the actual world (cf. Silverberg 1996: 220f). Yet, pragmatic factors and contextual considerations enter now as a constraint on similarity relations between worlds. That is, even if there are appropriate truth-conditions along these lines, the initial difficulty of spelling out what 'favourable', 'ideal', or 'normal' conditions are, recurs as the problem of specifying what counts as 'similarity of worlds'.

---

[5] This is not to say that none of the previous accounts could be subsumed under the heading 'semantic interpretations'. Pietroski and Rey's account, for example, culminates in a lengthy statement which starts, roughly: "'As are Bs, *ceteris paribus*' is nonvacuous(ly true) *if* each of the following conditions obtains…" (cf. Pietroski and Rey 1995: 92).

Ontology. As with epistemology centred accounts, the semantic approaches leave aside considerations about the ontological status of laws, or, quite generally, *what laws are*. There are, however, at least two accounts of *ceteris paribus* laws which turn directly to such metaphysical issues. Jerry Fodor's interpretation of *ceteris paribus* laws is based on the idea that special science laws are about complex objects (Fodor is most interested in human beings and their brains) the substructure of which could be altered or defective or missing certain elements so that the mechanisms on whose working the higher level law crucially depends are not in place (Fodor 1989: 75-6; 1991). Fodor's interpretation of *ceteris paribus* is, roughly, '*unless the appropriate substructure is not realised*'.

Part III of my inquiry could be seen as providing a more complex version of Fodor's account. Yet, its theme and purpose is different. In any case, it is important to point out again that Fodor's approach is focussed 'on what there is' and how it works. He does not focus on how language about laws functions or on how human beings use laws as tools for predictions or as inference rules.

The same holds for Nancy Cartwright who claims, first, that all laws are *ceteris paribus* laws as long as we regard their subject matter as being the regular observable behaviour of objects and, second, that a shift of that subject matter from behaviour of objects to dispositions of objects to behave would make laws strict.[6] According to dispositionalists like Cartwright, the move to dispositions provides a proper analysis of what is meant by the *ceteris paribus* clause, roughly, along the following lines: 'All Fs are Gs, *ceteris paribus*' *iff* all Fs have the disposition to be Gs.[7]

---

[6] She makes such claims in many of her books and articles: for example, *How the Laws of Nature Lie* (Cartwright 1983), *Nature's Capacities and their Measurement* (Cartwright 1989), *The Dappled World* (Cartwright 1999), etc.

[7] For a critical assessment of this approach see (Schrenk 2007).

V.
A NEW APPROACH TO *CETERIS PARIBUS* LAWS

I pointed out that not many theories of *ceteris paribus* laws are centred on metaphysical issues. Exceptions are Fodor's and Cartwright's interpretations. However, there is a certain metaphysical question about laws and exceptions that no-one has explicitly asked. This is either because it has been overlooked or its answer has been unreflectively taken for granted.

Remember that the most basic difficulty about the concept of a *ceteris paribus* law is that laws are generally thought to be at least strict universal regularities (whichever other conditions they have to fulfil). How, then, could they possibly have exceptions? The more specific problems of *ceteris paribus* laws as discussed above are, in some sense, corollaries of this fundamental tension.

Solutions that go the radical epistemic way circumvent this basic difficulty because here 'laws' become mere 'inference tickets' which might or might not allow us inferences in all circumstances. Further extending the ticket-metaphor, some tickets are VIP cards giving access to all areas, some are for the stalls only. The basic tension disappears because there is no requirement that inference tickets have to be VIP cards. In fact, it is even acceptable to think that it is *ceteris paribus* all the way down, i.e., that there are no 'all areas' tickets at all.

Yet, realists with regard to laws—i.e., those who believe that laws are something to be discovered in nature—might wonder why one law (now seen as something real) can be used as a VIP card but the other merely as an ordinary ticket. They could also ask the following question: are exceptions 'to the laws' always merely failures of their applications while the laws themselves are strict? Or could, in some sense, the laws themselves fail to hold? The answer might be 'yes'. If we trust Fodor's account, for example, then there could well be such a sense. Fodor's analysis claims that certain special science laws emerge from features of underlying structures. An exception to the law itself occurs when those underlying structures are disturbed, absent, or defect.

An intriguing question is, now, whether even fundamental laws (like, say, Fs are Gs) which do not originate in underlying structures could have exceptions: although almost all Fs are Gs, there are some which are not and, still, the relation between F and G is lawlike. Here, these exceptions would not be explainable by reference to destruction (or absence) of underlying structures.

The question whether there are viable concepts of lawhood—for fundamental as well as for non-fundamental laws—which allow the laws to have exceptions is the subject of this book. In other words, I aim to scrutinise the traditional conviction that laws, whatever else they might be, are (or give rise to) strict universal regularities.[8]

This question only makes sense against a background of certain assumptions and restrictions. One of the assumptions has emerged already: I have to presuppose realism about laws: whatever else they are, laws exist independently of any epistemic subject. They are discovered, not invented.[9] For a large part of this inquiry it does not matter precisely which realist theory of lawhood I adopt (this holds for the chapters on non-fundamental laws in Part III). Two major chapters are, however, dedicated to two famous theories of lawhood and their potential to incorporate the possibility of exceptions: David Lewis's theory (chapter 2.2) and David Armstrong's theory (chapter 2.3).

The examples I will use in this book mostly come from physics, chemistry, and biology. I have deliberately left aside sciences which might involve reference to human intentions, beliefs, and desires, like psychology and economics, for the reason that I neither want to be involved with the

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[8] We rarely get explicit answers to this question. I know of only one article which tackles it directly: Braddon-Mitchell's 'Lossy Laws' (Braddon-Mitchell 2001). In particular, Braddon-Mitchell refines David Lewis's account of lawhood and thereby attempts to show that it could cope with exceptions to even the most fundamental laws. Regarding Lewis I will later come to similar results and compare my findings to Braddon-Mitchell's.

[9] Since I presuppose realism I shall, from now on, use the term 'law statement' to mean the linguistic entity which (hopefully) picks out a law.

question whether these *really* count as sciences nor do I want to take on board problems related to the philosophy of mind and action.

I am also less interested in the dispute about the status of the special sciences and the value of their explanations or predictions (as underlined above, the issue of *ceteris paribus* laws and the status of special sciences is often discussed together).

I have nothing to say on the subjects of approximations and idealisations either, although these topics are undeniably related to the issue of *ceteris paribus* laws. An *approximation* could be seen as the process by which we deliberately focus on some aspects of a scenario while intentionally abstracting from certain other features. When calculating the orbit of the earth around the sun we might neglect the presence of other planets, for example, because their influence is only minute. *Idealisations* are theories formed about frictionless planes or ideal gases, etc. In some sense, they might be thought of as approximations cast into general theories. Idealisations describe the behaviour of things (or kinds of things) *as if* they were of such and such a constitution rather than of their real character. Both idealisations and approximations are intentional distortions of reality. They were never meant to be accurate. False statements, however, cannot pick out laws and since laws are my subject I will have nothing to say about idealisations and approximations.

Finally, I should mention that although I do not focus on the typical problems that arise from *ceteris paribus* statements I will, scattered in the book, offer some ideas of how to solve these difficulties.

VI.
OUTLINE

PART I—TWO DISTINCTIONS

Chapter 1.1: Real Exceptions versus Pseudo Exceptions. My first chapter distinguishes between two different kinds of exceptions to laws. In fact, only exceptions of one kind can count as real exceptions to the laws whereas the others, pseudo exceptions, are merely failures of predictions. This distinction has often been neglected in the literature on *ceteris paribus* laws; sometimes deliberately, e.g. in the purely epistemic and anti-realist accounts (see above), sometimes with the consequence that confusion looms. This book focuses entirely on real exceptions.

Chapter 1.2: Fundamental Laws versus Non-Fundamental Laws. In order to answer the central question of this inquiry—whether there is a concept of lawhood that allows for the laws to have *real* exceptions—it is beneficial to distinguish between fundamental and non-fundamental laws. (This distinction reflects the divide between the fundamental and the special sciences.) I have introduced one theory about how exceptions to non-fundamental laws might be possible: Fodor's theory. However, I will develop my own theories of such laws. In fact, I will define two types of non-fundamental laws (PART III). One type I call '*grounded laws*', the other '*emergent laws*'. First, however, I focus on fundamental laws (PART II).

PART II—FUNDAMENTAL LAWS

Chapter 2.1: General Considerations. In chapter 2.1 I turn to fundamental laws, not yet, however, to specific theories of lawhood, like Humean or necessitarian accounts. Rather, I first aim to uncover the preconditions for the possibility of the existence of fundamental laws with exceptions. A guiding question for this chapter is whether the world could be non-uniform to such an extent that it still shows enough regularity for laws to survive but too little regularity for these laws to be strict. I give a positive answer to this question. However, the almost strict regularities of such a messy world are, as far as this chapter goes, just *law candidates*.

Chapter 2.2 and Chapter 2.3: David Lewis's and David Armstrong's Theory of Fundamental Laws. It is only in chapters 2.2 and 2.3 that I inspect whether these candidates could justifiably be called 'laws'. For this second task it is indispensable to consult established general theories of lawhood. I discuss two prominent theories: as a representative of the Humean camp I have chosen the Ramsey-Lewis view; my spokesman for the anti-Humeans is David Armstrong.

PART III—NON-FUNDAMENTAL LAWS

Chapter 3.1: A general introduction to non-fundamental laws is given.

Chapter 3.2: Grounded Laws. Chapter 3.2 introduces the concept of grounded laws and analyses whether and how real exceptions to this kind of law are possible. I hope the concept of a grounded law is sufficiently inclusive so that the results of this chapter are true generally for a large class of non-fundamental laws.

Chapter 3.3: Emergent Laws. However, there is a second way to define non-fundamental laws which differs from the theory of grounded laws. I will introduce this approach, which is derivative of David Lewis's theory of lawhood, in chapter 3.2.

PART I

TWO DISTINCTIONS

1.1
REAL VERSUS PSEUDO EXCEPTIONS

The aim of this chapter is to make explicit a distinction between two ways in which a *ceteris paribus* clause attached to law statements can be interpreted. This distinction has not yet been made explicit.[1] A phenomenon one can observe when looking at capacities and powers rather than at laws can illustrate the distinction that is to be made: a disposition D to show manifestation M on test T can fail to be manifest although triggered because something counteracts against the (maybe partially manifested) effect M. Yet, there is a second possibility: the manifestation could also fail to occur because the disposition D (or its basis B) is lost or destroyed before the causal process from trigger T to effect M could begin or succeed.

Translated into laws we get the following distinction: a law might have an apparent exception (or falsification) because its consequent property is, while fully instantiated, counteracted or diluted by other events. Think of a multitude of forces (gravitational forces, electromagnetic forces, etc.) all acting upon a single body, an electron, for example. The law of gravitation alone will seem to have an exception if the other forces are disregarded in a prediction of the electron's trajectory.

Quite a different case would be the following: God decides to switch off, for a second or two, the gravitational force attracting the electron. This, as opposed to the first case, would be an example where we could justifiably claim that there is a real exception to the law.

On these grounds, I propose to distinguish what I will call '*pseudo exceptions*' from *real exceptions* where the *pseudo exceptions* are cases

[1] Neither has it been made explicit in many papers on *ceteris paribus* laws. Earman and Roberts' paper from 2002 is one of the exceptions (Earman & Roberts 2002: 285-6).

which, from the epistemic viewpoint of subjects making predictions, might *look like* violations of the law but really aren't. The law's consequent property is instantiated but diluted or masked or counteracted by other events happening at the same time. Real exceptions are a different issue: here laws themselves have exceptions. Their consequent property is indeed not instantiated at all (not even partially).

My ultimate interest is in the real exceptions. Once I have introduced my distinction properly I will put aside pseudo exceptions and ask, in the core chapters of my inquiry (chapters 2.1-2.3 & 3.1-3.3), whether there is conceptual/metaphysical space for laws to have real exceptions while still counting as laws.

1.1.1
TWO READINGS OF THE *CETERIS PARIBUS* CLAUSE

An example which is often given by those, like Nancy Cartwright, who advocate the soundness of the concept of a *ceteris paribus* law is Newton's law of gravitation. I will use it as an illustration for my distinction. The law says that masses *m* attract other masses *M* at distance *r* with the gravitational force $F_G = GmM/r^2$. I consider the special case of the earth and an overhead transparency. If we let the transparency drop, it won't fall according to the equation for the motion derived directly from the law of gravitation. There can be all sorts of interferences: air resistance, the blowing of the overhead projector's fan, electromagnetic forces due to electrostatic charge of the plastic, etc. Consequently, even the prototype of lawhood—the law of gravitation—seems to be a law with exceptions.

However, I find this story about the falling transparency confusing and my aim is to attract attention to the fact that there are two different ways in which we can interpret the phenomenon that a law is a *ceteris paribus* law, i.e., a law with exceptions. Newton's law of gravitation will, in the light of these new readings, be rehabilitated.[2]

Reconsider the falling transparency. I said that Newton's law of gravitation—F_G=GmM/r^2—is a *ceteris paribus* law because, apparently, the transparency does not fall according to the respective motion equation. This, however, was deceitful of me. (But I blame the people who are using Newton's law as an example for a *ceteris paribus* law.) Suppose we take other facts and laws on board, laws about air resistance, laws about electromagnetic forces, etc., facts about the charge the transparency is carrying, about the distribution of molecules in the air, etc. The description of the falling transparency will become more and more accurate. However, it is very important to note that while taking these other laws on board we do not suppose that Newton's law has changed, to 'F_G =½GmM^5r', say, or that its effects are entirely absent. Newton's law contributes to the falling of massive objects always the same force whether there are other forces around or not. Hence, Newton's law itself is in no need of a *ceteris paribus* tag. Its effect might be diluted or masked by other laws' effects, fair enough, but this is not to say that the law has an exception. Just as a dog does not stop being snappy if it is forced to wear a muzzle so the gravitational force does not disappear if an electromagnetic force counteracts it.

Quite a different scenario would confront us if the presence of charges were to switch off gravitational forces. This, as opposed to the case above, would be an example where we could justifiably claim that there is a real exception to the gravitational law for the consequence property, a force, is not there at all (as opposed to being counteracted against).

Therefore, if someone says a law is a *ceteris paribus* law we have to ask whether, (i), she means that, in many cases, events are not entirely covered and hence not describable by just this single law but only by many—I call this case '*exception by masking and diluting*' or '*pseudo exceptions*'—or, (ii), whether she indeed means that the law fails to be instantiated in this situation—I call this case '*real exception*'.

[2] Newton's law of gravitation is, of course, not a law at all. The law statement is false because of general relativity. I will use it nonetheless as my example. The reader can exchange it with any law statement he or she thinks picks out a real law.

1.1.2 EARMAN, ROBERTS, AND HEMPEL ON EXCEPTIONS TO LAWS

Precursors of my distinction—real versus pseudo exceptions—can be found in Carl Hempel's paper on proviso laws 'Provisos: A Problem Concerning the Inferential Function of Scientific Theories' (Hempel 1988) and Earman and Roberts' interpretation thereof (Earman and Roberts 1999: 442-8).[3] There, Earman and Roberts have correctly pointed out that Hempel's article on proviso laws does *not* advocate that *all laws* might be *proviso laws* as, for example, Fodor and Giere suggest: "Considerations recently raised by C. G. Hempel make it seem plausible that there are *no* strict laws of nature" (Fodor 1991: 21) and "[Hempel] says, laws are to be understood as containing implicit 'provisos' that qualify them" (Giere 1988: 39).[4] The confusion which lead people to this erroneous claim is precisely the one I formulated above. The distinction between *genuine exceptions to the laws* and *failed prediction based on ignorance of other laws* has not been made.

Earman and Roberts together with Hempel have uncovered this distinction and are far from making the strong claims Fodor and Giere read into Hempel's theory. However, Earman, Roberts and Hempel formulate the difference I endorse in different terms. They advocate a distinction between *theory* and *theory application*. In their terms, it is the latter, the application of theoretical laws, which might indeed always need a proviso:

[3] Sheldon Smith comes to similar conclusions in (Smith 2002).

[4] To be fair, it has to be said that Giere does not refer to Hempel's 1988 article (Giere's own article appears in the same book), but to lectures Hempel had given in 1970 (see endnote 3 of Gieres article).

> Note that a proviso as here understood is not a clause that can be attached to a theory as a whole and vouchsafe its deductive potency […] Rather, a proviso has to be conceived as a clause that pertains to some particular application of a given theory. (Hempel 1988, 26)

> Hempel's provisos are not provisos proper but are simply conditions of application of a theory which is intended to state lawlike generalizations that hold *without* qualification. […] Provisos […] must be attached to *applications of a theory* rather than to law-statements. (Earman and Roberts 1999: 444)

Without provisos attached to the *applications of a theory* (predictions for example) the theory is in danger of facing what I call *pseudo exceptions*.

How about real exceptions? On this matter we get a direct answer only from Earman and Roberts.[5] In principle, so it seems, they allow for this possibility in cases of laws that, in their terms, have a 'proviso proper':

> By a *proviso proper* we mean a qualification without which a putative law would not be a law, not because it lacks modal force but for the more fundamental reason that it would be false unless qualified. (Earman and Roberts 1999: 444; my italics)

They continue:

> The notion that it is provisos all the way down to fundamental physics can be motivated by the view that the world is a messy place and that we ought not to expect to find precise, general, exceptionless laws sans proper provisos. For all we know the world could be such a messy place. (Earman and Roberts 1999: 445-6)

However, it would be a mistake to accuse Earman and Roberts of accepting the possible existence of those laws too readily. We learn from a later article (written together with Sheldon Smith) that they are much more

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[5] It is difficult to figure out what Hempel's view on real exceptions is because it is not immediately clear whether Hempel can be called a realist regarding laws. Yet, realism seems to be a prerequisite for the meaningfulness of the question of whether laws can have real exceptions (yet, see my footnote 8 of this chapter). I hesitate to call Hempel a realist because of his predominant position in logical empiricism. Remember, for example, his semantic analysis of laws as true and lawlike statements (in his *Aspects of Scientific Explanation* (Hempel 1965)).—Earman and Roberts, on the other hand, can count as realists. Their preferred theory of lawhood is Lewis's best system analysis (even if they do not exactly praise it; cf. Earman and Roberts 1999: 461) and it is justifiable to qualify Lewis' theory as a realist theory.

sceptical concerning real exceptions. In this later article they start to doubt whether the step from the claim that the world is a messy place to the claim that there aren't any laws is valid:

> 'The world is an extremely complicated place. Therefore, we just have no good reason to believe that there are any non-trivial contingent regularities that are strictly true throughout space and time'. The premise of this argument is undeniably true. But it is very hard to see how to evaluate the inference from the premise to the conclusion. […] in the absence of any convincing reason to think that the inference from the premise of the above argument to its conclusion is a valid one, we see no reason to surrender to despair. (Earman, Roberts & Smith 2002: 292)

Even more strongly, they claim that

> A physical law with a CP clause that is ineliminable […] would be more interesting, and much of the literature is motivated by the belief that there are such laws (see, for example, Giere (1999) and Lange (1993, 2000)). However, it seems to us that there is no good reason to believe this, for the prominent alleged examples turn out upon scrutiny to be cases where the CP clause is eliminable. (Earman, Roberts & Smith 2002: 284)
>
> So far, the alleged philosophical problem of CP laws has yet to make an appearance in the realm of fundamental physics. (Earman, Roberts & Smith 2002: 284)

In conclusion, both Hempel and Earman, Roberts and Smith acknowledge the difference between real and pseudo exceptions (even if seen from a different angle: theory vs. theory application). However, Earman and Roberts are sceptical about the existence of fundamental laws with real exceptions.[6] It remains to be seen in PART II whether we should

[6] I know of only one philosopher who actively defends the existence of fundamental laws with exceptions. Nancy Cartwright's view is radical indeed: "For all we know", she writes, "most of what occurs in nature occurs by hap, subject to no law at all." (Cartwright 1999: 1) Of course, Cartwright oscillates between referring to regularities and to ascriptions of capacities when she uses the word 'laws'. This makes it difficult to decide how we should interpret this radical claim. If we suppose she means 'subject to no capacity at all' then her claim would, indeed, be a claim to the effect that even the most fundamental laws/capacities are infected by real exceptions. Other quotes make that plausible: "For any body in any situation, *if nothing intervenes*, its acceleration will equal the force exerted on it divided by its mass. But what can interfere in the production of motion other than another force? Surely there is no

agree with them.

1.1.3 FAILING TO DIFFERENTIATE BETWEEN PSEUDO AND REAL EXCEPTIONS

Note that if we focus on the epistemic business of predictions with the help of the laws (rather than on the laws themselves) the difference between the two cases—illusion of exception and real exception—is easily overlooked and has frequently been neglected in the literature:[7] although many alleged exceptions to laws stem from omissions of additional factors in predictions the conclusion philosophers draw is that the laws themselves have the exceptions. This is understandable in so far as a failed prediction does not wear on its sleeve that factors were omitted or that the law really has an exception. Further research is necessary in each individual case to establish which of the two has happened. In many cases (if not all) it will be the prediction rather than the law which needs the *ceteris paribus* tag.

Poincaré, for example, comes to the conclusion that the laws themselves are only 'approximate' although his example is an instance of unpredictable interferences as opposed to real exceptions to the laws:

> Take the law of gravitation, which is the least imperfect of all known laws. [...] I announce, then, with a quasi-certitude that the coordinates of Saturn at such and such hour will be comprised between such and such limits. Yet is that certainty absolute? Could there not exist in the universe some gigantic mass, much greater than that of all the known stars and whose action could make itself felt at great distance? That mass might be animated by a colossal velocity [...] it might come all at

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problem. The acceleration will always be equal to the *total* force divided by the mass. That is just what I question." (Cartwright 1999: 26) Also, Earman and Roberts seem to read her in the strongest way: "Cartwright concludes, however, that there are no strict lawlike regularities in nature at all, not even ones that can be only stated in a richer vocabulary that mentions capacities." (Earman & Roberts 2000: 475, endnote 27)

[7] Epistemic accounts of *ceteris paribus* laws (as mentioned in the introduction) fail to distinguish both cases.

> once to pass near us. Surely it would produce in our solar system enormous perturbations that we have not foreseen. [...] For all these reasons, no particular law will ever be more than approximate and probable. (Poincaré 1958: 130)[8]

Or consider a remark of Pietroski and Rey's: "Given current science, the appropriate question would seem to be whether *any* laws are strict." (Pietroski and Rey 1995: 88) Why is this so? Is it because *current* science has not yet found the real laws? Or is it because the laws are indeed themselves *ceteris paribus*? I am inclined to believe that it is neither of these two possibilities. There is rather the confusion of real exceptions to the laws and cases of illusions of exceptions at work: Pietroski and Rey's remark is motivated by the observation that predictions often go wrong where they then blame the laws for this failure. Consider a second of their remarks:

> We want to say, recall, that the law of gravity holds, other things being equal. But other things are not equal when protons and electrons are the bodies in question, since these bodies also have charge. (Pietroski and Rey 1995: 105)

I am inclined to ask which law or relation it is, if not Newton's law, that holds between a mass and a force where there are charges around as well. The answer is, of course, that it is still Newton's law and this amounts to the fact that the law holds even when other things are *not* equal.

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[8] To do full justice to Poincaré I would, of course, have to take his instrumentalism into account: if, in short, the laws are just the best instruments to predict future phenomena then my distinction between exceptions to predictions and exceptions to the laws themselves (pseudo vs. real exceptions) seems, *prima facie*, to break down. However, a reformulation of my distinction along the following lines might be acceptable to the instrumentalist (or any anti-realist): a real exception is a case in which the instrument can, to our surprise, not be used at all (it is not applicable); a pseudo exception is a case in which we did not make use of all the relevant instruments. (If, as Worrall has suggested, Poincaré is a *structural realist* rather than an instrumentalist the difficulty disappears by itself (cf. Worrall 1989: 158).)

1.1.4
EXCURSUS: XIAN PARTICLES

An astonishing case of peculiar pseudo exceptions are 'Xian particles'. Xia (Xia 1992) showed—using a classical Newtonian system of five point-masses—that

> one might somehow arrange for one of the point masses to accelerate in a given spatial direction, ever more rapidly and at so great a rate, during a period of time, in such a way that it does not exist in space at the end of the period! By that time, it has disappeared to 'spatial infinity'. (Butterfield 1998, 2005)

Symmetry assumptions show that such Xian particles, Earman (in Earman 1986) calls them 'space invaders', could equally well appear in space unpredictably:

> Since the time reverse of this system is, of course, equally allowed by Newton's laws, it is possible in a Newtonian universe that at any moment, five (time reversed) Xian particles suddenly appear from spatial infinity. In such a case, the positions and the velocities of other particles (which were there before the Xian appearance) would of course not determine the time and precise character of the appearance before it happens […] such Xian 'space invaders' could arrive at any moment and disturb the given particles. (Schmidt 1997: 438)

Note that the unpredictability of the invasion is not due to a deficient *human* epistemology, but due to how mysteriously the world could behave. Hence, this unpredictability is inherent in any forecast (for any epistemic subject, even for omniscient beings, provided they cannot look into the future). Yet, Xia still remains a case of a pseudo exception since the laws would not change in the presence of a Xian particle. In the unfortunate case of a disturbance to a system by Xian or similar particles the disturbance is, after the fact, well explainable and in accordance with the laws of nature.[9] I conclude with Mill:

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[9] To be fair I have to mention that Schmidt also underlines that "universes [with Xian particles] are felt to be somehow 'unlikely' or 'physically unreasonable'." (Schmidt 1997: 438) After having defined the notion of physically reasonableness Schmidt goes on to claim that our universe is more likely to be reasonable than not.

> When in every single instance a multitude, often an unknown multitude, of agencies, are clashing and combining, what security have we that in our computation *à priori* we have taken all these into our reckoning? How many must we not generally be ignorant of? Among those which we know, how probable that some have been overlooked; and, even were all included, how vain the pretence of summing up the effects of many causes, unless we know accurately the numerical law of each,—a condition in most cases not to be fulfilled; and even when it is fulfilled, to make the calculation transcends, in any but very simple cases, the utmost power of mathematical science with all its most modern improvements. (Mill 1843: 460)

1.1.5 REAL EXCEPTIONS: THE FOCUS OF THE BOOK

In the previous section I have suggested that the failure to distinguish between real exceptions and the pure illusion of exceptions to the laws has led philosophers to the wrong conclusion that almost all laws (including fundamental laws like the law of gravitation) are laws with exceptions. The confusion between the two cases has its origin in neglect of the distinction between laws and prediction with laws. The conclusion from a failed prediction to the claim that laws themselves have an exception is, however, a fallacy. In the rest of this investigation I focus on real exceptions. That is, I ask the following questions:

- How are real exceptions to laws possible (if they are possible)?
- Can laws themselves, not only our predictions, have exceptions?
- Is universality a necessary condition for lawhood?
- Suppose we were omniscient and knew all the laws and all the details of a certain situation could we still face exceptions?[10]

Or compare the issue of proviso laws with what we believe about genuinely probabilistic laws: the uncertainty of quantum processes, nuclear decay, for example, "is not simply the result of our ignorance of all the

[10] I do not claim that these questions are synonymous. They are only meant to indicate the direction of my inquiry.

little forces and influences that try to make the nucleus decay; it is inherent in nature itself, a basic part of quantum reality." (Davies 1996: 33) What I am looking for are laws with exceptions which are "not simply the result of our ignorance of all the little forces and influences *but exceptions that are inherent in nature itself, a basic part of reality*".

The question of whether we can have a concept of laws of nature that allows the laws to have real exceptions as opposed to the illusion of an exception usually triggers astonishment if not immediate dismissal as an intuitive response. Phrased in this up-front way and not veiled in Latin words ('Are there any *ceteris paribus* laws?') many people reject the idea of laws with exceptions straight away. There are two good reasons to do so. (i) Generations of philosophers working on the nature of laws have presupposed that "laws of nature, whatever else they might be, are at least exceptionless regularities" (Lewis 1986: xi).[11] The *Oxford Dictionary of Physics* states, for example, that "any exceptional event that did not comply with the law would require the existing law to be discarded or would have to be described as a miracle" (OUP 2000: 260).

The second reason, (ii), is simply that one of the main arguments in favour of the existence of laws with exceptions are not tenable. This faulty argument is, as shown above, based on ignorance of the distinction between real and pseudo exceptions.

In the rest of this book I will challenge the creed, (i) that laws must be exceptionless regularities. However, it is not my aim to supply those philosophers who have launched the false argument (ii), with a correct argument for the existence of *ceteris paribus* laws. My aim is less ambitious: I deliver a conceptual analysis that tells us whether the concept of lawhood goes together with the possible existence of exceptions. My analysis will be modestly positive. The actual existence of these laws is, of course, a matter which is to be settled empirically.

[11] In chapter 2.2, I will point out that Lewis himself is not quite that strict. I will show that laws with real exceptions are an acceptable, if not even an accepted, possibility for Lewis.

1.1.6
SUMMARY

I have distinguished what I call '*pseudo exceptions*' from *real exceptions* where the pseudo exceptions are cases which might *look like violations* of the law but really aren't. In pseudo exceptions, the instantiation of the law's consequent property is merely diluted or masked or counteracted. Real exceptions are a different issue: here, laws themselves have exceptions, that is, the laws' consequent property is indeed not instantiated.

1.2
FUNDAMENTAL VERSUS NON-FUNDAMENTAL LAWS

In order to reach an answer to the core question of the book, it is helpful to divide the realm of laws into *fundamental* and *non-fundamental* laws. The fundamental ones could roughly be characterised as those that involve basic properties of basic entities. They are those laws most of the general theories of lawhood aim to characterise; whether these theories are Humean regularity theories or those favouring some anti-humean connection in nature. I will limit my inquiry to two such theories, that is, I will ask how David Lewis's best system analysis (chapter 2.2) and David Armstrong's theory involving nomological necessity (chapter 2.3) could cope with exceptions to laws. As will become clear in the respective chapters, Lewis's analysis (or a slight variation thereof) can allow much easier for exceptions than Armstrong's.

Non-fundamental laws are those laws that are about complex objects and their interactions. Contrary to the fundamental laws, there is no recognised catalogue of orthodox theories for non-fundamental laws. Therefore, as opposed to my chapters on fundamental laws where I could rely on some traditional theories, here I have to introduce my own concepts. I have some hope that the ideas I have to offer of what viable characterisations of non-fundamental laws are could be valuable in their own right. However, they were primarily developed with the goal to test whether a concept of non-fundamental laws is possible which allows these laws to have real exceptions. The two distinct kinds of non-fundamental laws I will introduce are what I call '*grounded laws*' and '*emergent laws*'.

Grounded laws (chapter 3.2) are laws whose law character derives from the underlying structures of the objects they are about plus the more fundamental laws about those underlying structures. As an example consider the laws of molecular chemistry which depend on specific molecular structures plus quantum-mechanical laws.

The alternative, *emergent laws*, are about non-fundamental objects no matter whether their regularity stems from or depends on the substructure of these objects and any underlying laws or not. They therefore cannot gain their law-status from any such underlying structures or laws. Rather, I locate the source for their lawlikeness in that the respective law statement belongs to a system of statements which describes the class of phenomena it is concerned with (chemistry, biology, etc.) in the simplest and strongest way. Obviously, this idea derives from Lewis's theory of fundamental laws, here applied to non-fundamental entities of higher order sciences. How this is supposed to work will be shown in chapter 3.3.

A Comparison to Chance. We can compare the difference between fundamental laws with real exceptions and non-fundamental laws with real exceptions to the distinction between *genuine probabilistic laws* (like laws from quantum mechanics) and so called *statistical laws* (like 'smoking increases the probability of lung cancer'). The statistical law is said to be generated from more basic laws and complex structures. It is the complex underlying structure from which the chanciness originates. The chanciness of genuine probabilistic laws, in contrast, does not stem from underlying secrets.

(There is, of course, an element of chanciness in statistical laws like $p(G|F)=r\%$ which is not due to underlying structures: even though one could in principle predict the outcome of an individual event *f* with certainty if one knew everything about the underlying mechanism it would still be a matter of further research (not tied to the underlying mechanisms) why r% of Fs are G.)

PART II

FUNDAMENTAL LAWS

2.1
FUNDAMENTAL LAWS: GENERAL CONSIDERATIONS

2.1.1
INTRODUCTION

Can there be a concept of *fundamental laws* which allows these laws to have real exceptions? The prospect of the existence of such laws sounds bleak for it cannot be denied that real exceptions to those laws usually count straightforwardly as falsifications. Even more so when we contemplate the way science works:

> We […] claim that the history of physics and the current practice of physics reveal that it is the goal of physicists to find […] strict, proviso free laws. Obviously we cannot rehearse that history here, but we believe that a fair reading of it shows that when exceptions are found to the candidates for fundamental physical laws, and when the theorists become convinced that the exceptions cannot be accommodated by explicitly formulated conditions in the language of the theory, the search is on for new candidates. (Earman & Roberts 1999: 446)[1]

Methodologically, physics looks for flawless generality and every exception to a law-hypothesis is a strong incentive to drop the hypothesis and formulate a new law.[2] The belief in a fundamental principle, namely

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[1] That hasn't changed since Hume's Treatise in 1739/40: compare to number 6 of his "general rules, by which we may know when they [cause and effect; MAS] really are so [i.e., cause and effect; MAS]" (Hume 1739/40: 173; Book I, Part III, Section XV): "For as like causes always produce like effects, when in any instance we find our expectation to be disappointed, we must conclude that this irregularity proceeds from some difference in the causes." (Hume 1739/40: 174; Book I, Part III, Section XV)

[2] Or even to reform our conceptual scheme: "Persistent serious failure of a theory may lead to a revolution in Kuhn's sense, which places the phenomena into a novel

the uniformity of nature, is at the heart of this scientific method. The success of science and, on a more abstract level, the success of induction in general seems to justify our belief in this uniformity.

Yet, nature might not be kind to us and less than perfect regularities could be the norm. Could we nonetheless find *laws* in an irregular world? Could the world be messy in such a way that it still shows enough regularity for laws to survive but too little regularity for these laws to be strict? The odds stand against us but in what follows I hope to show that this is possible.

The Agenda. I will investigate whether there is conceptual space for *fundamental laws*[3] *with exceptions* in two steps:

> (A) Step one (a kind of transcendental step) aims to uncover the preconditions for the possibility of the existence of laws with exceptions. Amongst other things, the task is to look at regularities 'with impurities' and the respective law aspirants covering these regularities which have exceptions where the impurities occur. These law aspirants will, as far as step one is concerned, just be *law candidates* (chapter 2.1).
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> (B) It is only in the second part of the investigation that I will inspect whether these candidates could justifiably be called laws or whether they only deserve a title like 'rough guidelines of what is happening'. For this second task it is indispensable to consult general theories of lawhood: the rough regularities will be honoured with law status *if and only if* they can be accommodated by general theories of lawhood or close derivatives thereof. I will discuss two such theories: as a representative of the Humean camp I have chosen the Ramsey-Lewis view; my spokesman for the anti-Humeans is David Armstrong (chapters 2.2 and 2.3).

An Appetiser. Before I start with step one I would like to serve an appetiser for the second step to come—the inspection of theories of lawhood—in order to convince the reader that the enterprise is not hopeless from the outset.

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theoretical framework rather than modifying the old one by piecemeal changes." (Hempel 1988: 33)

[3] Where no confusion is likely to arise I will, in this and the next chapters (2.2 and 2.3), use the word 'laws' synonymously for 'fundamental laws'.

An early logical empiricist idea of how to distinguish laws from accidents was to claim that law statements—as opposed to sentences that state pure accidents—are true universal statements whose predicates are scientifically kosher (that is, for example, predicates which are projectible or refer to *perfectly natural* properties). This criterion failed. Of the following two syntactically and semantically alike statements—both are universal quantifications and both containing only scientifically respectable predicates—the first is a good candidate for a law, the second is not:

1. All solid spheres of enriched uranium (U235) have a diameter of less than one mile.
2. All solid spheres of gold (Au) have a diameter of less than one mile.[4]

Philosophers have concluded that in order to distinguish laws from accidental regularities a stronger criterion has to be formulated: a law statement must be a universal generalisation quoting scientifically respectable predicates *plus some X*. Many Xs have been suggested since: by anti-Humeans, for example, *natural necessity* as a relation between the universals the generalisation's predicates refer to, or, by Humeans, *membership in an optimal deductive system* which describes the world in the best balance of simplicity, strength and fit.

My idea for the second task, (B), is, now, this: even *approximate* generalisations *plus X* might count as laws. The hope is simply that we have overpaid the bill with the X additional to generality such that we can demand cash back which comes in the currency of exceptions.[5] Of the two

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[4] Cf. Reichenbach in his *Elements of Symbolic Logic* (Reichenbach 1947: 368). Note aside that it might be possible to solve this specific riddle via my grounded law / non-grounded law distinction (cf. chapter 1.2 and 3.2). The uranium law is a grounded law, not a fundamental one. It is grounded in the mechanisms of atomic decay and chain reactions kicking off when sufficiently many uranium atoms stick together. However, there are no such underlying mechanisms in the case of the golden spheres and hence it is not a grounded law. (The alleged law about the golden spheres could, of course, to our astonishment be a fundamental law.)

[5] "We maintain that whatever distinguishes *ceteris paribus* laws from merely contingent *ceteris paribus* generalisations is just whatever distinguishes strict laws

Xs mentioned above Lewis's X (best systems) will turn out to be better suited for the task. Only a minor change to his theory makes the X so rich that it can pay for the exceptions (see chapter 2.2). The necessitarians, I will argue, have to face serious metaphysical difficulties if they want to try to incorporate the possibility of exceptions into their theory of lawhood. However, there are some possibilities that they can accept (see chapter 2.3). This, then, is the program for the present and the next chapters.

2.1.2 AVOIDING TRAPS

I turn now to task (A). What do possible law candidates with exceptions look like? There are two traps one has to avoid in the hunt for those candidates: these candidates should not turn out to be strict regularities in disguise—that is the case if it is possible to add further factors (or exclusion clauses) to the antecedent of the respective general statement to reach a formulation of a strict general statement—nor should the candidates turn out to be disguised probabilistic laws. I will call the first trap the *epistemic trap* because it would simply declare an as yet incomplete law-hypothesis a law[6] and the second one (for obvious reasons) the *probabilistic trap*.

In what follows, I will, in chapter 2.1.3, construct law candidates with exceptions which, I hope, will avoid both the epistemic and the probabilistic trap. In chapter 2.1.4 I will examine existing phenomena like black holes and other singularities which come surprisingly close to candidates for lawless space-time points and, hence, for points of exceptions for many laws.

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from contingent strict generalizations." (Earman & Roberts 1999: 461) Earman and Roberts' "whatever" is my X.

[6] Braddon-Mitchell has something like the epistemic trap in mind when he says: "The point is that *systematic* violation of a law is not violation, it makes true different laws." (Braddon-Mitchell 2001: 272)

2.1.3 CANDIDATE 1: INDEX-LAWS

Suppose we have a candidate for a fundamental law, 'Fs are Gs', but at a certain space-time point this candidate has an exception. Suppose furthermore that this space-time point cannot be distinguished in kind from other places and times where the law candidate holds. This is to say, it is impossible to single out the exceptional case by means of a general description of circumstances in which it occurs.

I claim that such a candidate with such a type of indescribable exception escapes the epistemic and the probabilistic trap. Before I show this I will introduce a proper definition and compare my candidate to an example from the literature.

Define an **index-regularity** in the following way:

> (x, y, z, t) is an **ind**ividual **ex**ceptional space-time region[7] (an **index**) for regularity R iff R has an exception at (x, y, z, t) *and* there is at least one other space-time region (x', y', z', t') which is exactly alike in circumstances—that is, alike in intrinsic, non-relational properties—but where the regularity does not have an exception.
> An **index-regularity** is a regularity R which has an index.

For clarification, recall that I am only at the stage of finding law *candidates*. That I have been twice at a certain café in Cologne where I have ordered once an espresso, once a cappuccino might make 'Whenever I go to that café I order espresso' an *index-regularity* but surely not an index-*law*. Yet, note that we have to suppose that the circumstances in which I ordered the exceptional cappuccino have to be indiscernible from those in which I have ordered the espresso. Also note that I presuppose that we are concerned with fundamental regularities which are unlikely to involve people, cafés and types of coffee. Last but not least I still have ingredient X up my sleeve which is my joker in step (B) (see the chapters on Lewis and Armstrong). These are reasons why coffee-regularities like

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[7] To signify a region rather than a point in space-time I should write (x+Δx, y+Δy, z+Δz, t+Δt) but for shortness of expression I allow myself the briefer (x, y, z, t).

the one mentioned are ultimately no danger to the index enterprise.

For further clarification we can compare *indices* to *Smith's garden* (Tooley's anecdote in (Tooley 1977)) where some unfamiliar laws hold:

> All the fruit in Smith's garden at any time are apples. When one attempts to take an orange into the garden, it turns into an elephant. Bananas so treated become apples as they cross the boundary, while pears are resisted by a force that cannot be overcome. Cherry trees planted in the garden bear apples, or they bear nothing at all. If all these things were true, there would be a very strong case for its being a law that all the fruits in Smith's garden are apples. And this case would be in no way undermined if it were found that no other gardens, however similar to Smith's in all other respects, exhibit behaviour of the sort just described. (Tooley 1977: 686)

A difference between Smith's garden and indices is that Tooley focuses on the new and surprising laws in the garden whereas my focus is on the laws elsewhere. I am tempted to call my indices *Bakunin's garden*[8] for they are supposed to be places of anarchy (or gardens overgrown with weeds).[9]

Goal missed? Yet, why do I hope to have eluded the *epistemic trap?* Couldn't indices be excluded in the antecedent of the law candidate as much as general circumstances can? Think of ∀u (Fu ∧ ¬@(x, y, z, t)u ⊃ Gu), with '@(x, y, z, t)u' abbreviating that the event *u* happens at the truly individual exceptional space-time region (x, y, z, t) (or, respectively, that the object *u* is placed at the space-time region (x, y, z, t)). We could even create a predicate C*—*C*u iff* u is at (x, y, z, t)—such that, on the grammatical surface, no singular term appears in the antecedent: ∀x (Fx ∧

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[8] Bakunin, Michail Aleksandrowitsch (1814-1876), Russian anarchist.

[9] There is another example of Tooley's kind in the literature. When Moritz Schlick (cf. Schlick 1938: 48ff) considers a principle he attributes to Maxwell and which says that under the same circumstances things happen exactly alike *in every place and at any time* Schlick acknowledges the possibility of this actually not being so. More specifically, Schlick rejects that Maxwell's principle is a necessary condition for lawhood and imagines a world in which there are laws that have space-time location as one of their variables—i.e., the value of these laws is also dependent on where and when things happen. Schlick's example is more akin to Smith's garden than to the radicalised index version but it shows the general willingness of a member of the Vienna Circle to acknowledge something like the possible existence of laws with exceptions.

$\neg C^{*}x \supset$ Gx). Therefore, one could claim that, with these amendments, a different law is made true just like in the case of generally specifiable systematic violations. It seems that for the goal of finding law-candidates with exceptions no progress has been made because index-regularities fall victim to the epistemic trap.

I will argue against this conclusion. For this purpose, a little detour is necessary: the whole affair might remind us of discussions about lawhood in mid-20th-century philosophy of science. Back then, the verdict was that nothing should count as a law if it is just a regularity true of a single thing (or a few things) or a particular space-time region. Loosely speaking, laws should be true generally of everything everywhere. Translated into a syntactical criterion philosophers demanded that law statements should not include singular referring terms:

> In physics, the idea that a law should not refer to any particular object has found its expression in the maxim that the general laws of physics should contain no reference to specific space-time points, and that spatio-temporal coordinates should occur in them only in the form of differences or differentials. (Hempel 1948: 267; fn. 28)

However, if one tries to exclude individuals simply by syntax one is bound to fail. This is so because every singular term, the name 'Hans', for example, can easily be turned into a predicate true only of the individual the name refers to: x is H $iff_{\text{def.}}$ x is identical to Hans. Superficially, this procedure debars Hans from figuring in laws; on a closer look, however, we have only debarred 'Hans' and Hans comes in through the backdoor. That is, Hans enters through the meaning of the predicate H. Individuals are only superficially excluded by fiddling around with language. It was at this point that the endeavour to define, in purely syntactical terms, when a statement counts as lawlike failed.

Here, I return to my own concern, namely arguing that *index*-regularity statements are not to be interpreted as new statements about exceptionless regularities but rather that we can justifiably interpret them as picking out law-candidates with exceptions.

There are two welcome differences between my aim and the 20th century empiricists' search for criteria of lawhood just mentioned. First, whereas in those discussions of lawhood individuals[10] were *persona non grata* I am quite keen to have them in. Hence, for me (as opposed to them) it comes as a welcome result that individuals cannot be hidden easily, that is, even if you can hide *indices* in the syntactical surface of an antecedent of a law statement behind a predicate you will still, implicitly/semantically, refer to the individual space-time region. That is to say that the surface grammar might give you the illusion of a strict regularity but on a closer inspection the law candidate that is picked out by that seemingly spotless surface is a law with an exception. The state of affairs this statement describes is clearly a general pattern with one little gap.

So far, so good, but the reason for philosophers to keep individuals out was that they wanted to deny law status to regularities which involve individuals. Now, this surely counts against my enterprise? Here the second difference between the empiricist enterprise and mine comes as a helping hand. As mentioned before, the reason for philosophers to deny law status to regularities when they involve individuals was that they wanted to avoid *regularities that are restricted* to certain space-time regions or to certain singular entities. Cases like 'All coins *in my pocket* are silver' were to be excluded. My concern is complementary: I want to include reference to individual space-time regions *where the otherwise general regularity does not hold*. In short, the individuals I want to grant asylum to are not of the kind that the history of philosophy of science wanted to exclude. I therefore consider the epistemic trap to be avoided.

I will discuss a variant of the epistemic trap in my chapter on David Lewis's account. In fact, this variant which, by a clever shift of perspective, manages to reinterpret any good candidate law with exceptions as a strict law threatens my enterprise recurrently. In each consecutive chapter I will give warning when it appears.

Are index-regularities probability laws? I have given warning of two possible traps we could fall into when trying to conceive of non-grounded laws with exceptions: I have disarmed the epistemic trap. In fact, my current candidate laws—index-laws—were constructed with the aim of

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[10] Or better: reference to individuals in scientific language.

avoiding the epistemic trap in mind. **The probabilistic trap** awaits us now. The problem is that index-laws might be interpreted as probabilistic laws with a very high positive probability. Instead of $\forall u\ (Fu \wedge \neg@(x, y, z, t_0)u \wedge \supset Gu)$ we would have $\forall u\ p(Gu|Fu) \approx 1$ (obviously, the more *indices* the lower the probability). Fodor, for example, writes: "If they [fundamental laws, MAS] have exceptions that *must* be because they're *nondeterministic*." (Fodor 1989: 76; my italics) I have three reasons to reject Fodor's conclusion.

I want to present the first reason in a quasi epistemic way: we lose information when we translate the index-law candidate into a probabilistic law. Suppose you were the captain of a spaceship in the year 2301. Of course you have a degree in physics and you have learned that Coulomb's law is (surprise!) an index-law and that a well known place in the Dagobar star system is such an index. That is, instead of our

$$\forall(x, y, r)\ [\ \text{Charge}(x)=q \wedge \text{Charge}(y)=Q \wedge \text{Distance}(x, y)=r \supset \text{Force}(x, y) = qQ/(4\pi\varepsilon_0 r^2)\ ]$$

you have learned that

$$\forall(x, y, r)\ [\ \text{Charge}(x)=q \wedge \text{Charge}(y)=Q \wedge \text{Distance}(x, y)=r \wedge \neg@Dagobar(x) \wedge \neg@Dagobar(y) \supset \text{Force}(x, y) = qQ/(4\pi\varepsilon_0 r^2)\ ]$$

Suppose your Martian enemy has instead been taught by her physics tutor *Fodoros* that Coulomb's law is a probabilistic law with an extremely high probability (the short version of which is: p(Coulomb-Force | qQr) = 99.99%)). Her general survival strategy will be to assume (although she knows that it is not exactly true) that Coulomb's law always holds. What can she do, after all, to prevent it from failing randomly? Therefore, you would be in an advantageous position in that space duel: you would lead the Martian into the Dagobar system and observe her disintegration.

This sci-fi epistemology is based on serious metaphysics. Everywhere in the universe, so is the claim, except for the space-time region called Dagobar system (or a tiny spot therein) Coulomb's law is an exceptionless law. Hence, it is simply wrong to translate it into a probabilistic law which would claim that, wherever you are, there is an objective chance that two charges do not attract (repel) each other. In fact, the probabilistic claim is true nowhere: neither at the index where the probability is 0 nor anywhere else where the probability is 1. Hence, index-laws are not to be equated with probabilistic laws at all.[11]

The second point against treating index-laws as disguised probabilistic laws is that genuine probabilistic laws—as we know them since the discovery of quantum mechanics—are still in accordance with conservation principles, like the conservation of energy, momentum, etc.

> The lesson of quantum physics is this: Something that "just happens" *need not actually violate the laws of physics*. The abrupt and uncaused appearance of something can occur *within the scope of scientific law*, once quantum laws have been taken into account. (Davies 1996: 33; my emphasis)

Yet, index-laws as described above might violate those principles: if, for example, at (x, y, z, t) the gravitational force stops then at least the laws of energy and momentum conservation break down as well. These laws, too, are index-laws then.

My third argument for the difference between *index*-laws and probabilistic laws is that if laws are interrelated in the way my second point urges then it is never only a single law that fails at an anarchical space-time point but many. Yet, if all those laws failing were probabilistic laws (instead of laws with exceptions) then their failing together would be a possible, although an enormously unlikely event because the individual probability for each of them to fail at a certain space-time point is already supposed to be extremely low.[12]

I conclude: if a world contains small and rare anarchical space-time regions and is otherwise as regular as we think our world is then that world is a good candidate for having laws with exceptions. The respective law

[11] This is not to deny that, for epistemic subjects like human beings, it might be very difficult (if not impossible) to find out whether a law is an *index*-law or a probabilistic law. Note that the above case is still a very lucky one because I have assumed that the *index* is spatiotemporally extended at the Dagobar system. This need not be the case. Tiny, point size *indices* could be widely and randomly distributed in space and time.

[12] Unless, of course, the laws' interrelatedness is (partially) a conceptual/analytical matter (as, for example, for force, impulse, and energy). A similar point has been made by Braddon-Mitchell (cf. Braddon-Mitchell 2001: 274).

statements of these laws can be characterised by the following general scheme: $\forall u\ (Fu \wedge \neg @(x, y, z, t)u \supset Gu)$. Both the epistemic and the probabilistic trap are avoided.

Indices—a slippery slope? My second reason to distinguish index-laws from probabilistic laws was to point out that the existence of an index for, *prima facie*, one single law probably means the downfall of more than one law: our laws form a net such that the anarchy which we assumed was restricted to one law easily turns out to be a widespread revolution. I fear I simply have to bite this bullet.

Even more is to come: supposedly local indices could have global effects in yet another sense. Suppose that a big mass moves into a non-gravity index. Does that mean that the mass' gravitational effects fail only inside the index or are they also lacking outside that region? If the latter, then the event of the mass entering the index might have catastrophic effects in the whole universe. If the former, i.e., if from the surface of the index outwards everything is business as usual, then the index's effect remains localised. However, the restricted anarchy requires us to accept two anomalies: the exception inside the index itself *plus* its annihilation at the surface. That sort of index would be a strange animal: not only does it swallow gravitation—to the outside world it also makes it look as if it didn't. I think, for that reason, that exceptions plus annihilation sounds so far fetched that indices with global effects are more credible.[13] Hence, let me try to make this version (with possible global effects) more palatable.

For a start, note that this second kind of global effect concerns only contingent facts; no further laws are thereby violated (remember the first slippery slope which also effected related laws). Moreover, we can think of indices as being very small. They could be microscopic phenomena: tiny space-time regions with negligible extension or even space-time *points*. The mess they would cause is, for these two reasons, limited and so the

[13] I do not say that worlds with this kind of self-annihilating indices are conceptually impossible. Yet, my only goal is to find *one* possible scenario that could host laws with exceptions. So, I might as well just go for the more acceptable one and leave the other aside. I can turn back to self-annihilating indices in case the other route is not successful.

enterprise to find the preconditions for the possibility of the existence of laws with exception not yet doomed to failure.[14]

What exactly happens at indices? So far, I have not made any assumptions about what exactly happens at an index despite the fact that Fs would not be Gs (if 'Fs are Gs' is the law under concern). There are essentially three alternatives:

(1: Chaos). At various indices Fs could be something else: here Hs, there Is, then Js, etc. in a random fashion. They might also have no further property at some indices. Here's a fictitious example: at (x_1, y_1, z_1, t_1) masses do not attract each other, they repel each other; at (x_2, y_2, z_2, t_2) masses do neither attract nor repel each other; at (x_3, y_3, z_3, t_3) masses behave like negative charges, …

(2: A Blessing in Disguise); short (2: Blessing). There could be a regularity within the irregularity: at (x, y, z, t), and the few other indices, all Fs are Hs.[15]

(3: Nothingness). None of the Fs has any further property at the indices.[16] This is the case I have tacitly assumed so far. (This last possibility could be seen as a derivative of (2: Blessing).)

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[14] If there were extended indices with global effects in our world then the probability would be high that we discover them sooner or later. Turning this argument upside down we might also say that, since we have not yet discovered indices, our empirical data counts against their existence in our universe. However, tiny index-points could still exist even in our world because the global effects would be minute and almost undetectable. –
On the subject of singularities (the next candidate for exceptions I discuss) Earman notices the problems more influential exceptions would cause. He tries to abate the anxieties: "Such fears about the unbridled influences of naked singularities would be somewhat assuaged if it could be shown that a naked singularity can have only a minimal influence on external observers." (Earman 1995: 94)

[15] Alternatives (1: Chaos) and (2: A Blessing in Disguise) do not differ where there is only one index.

[16] Remember that we are talking about ultimately basic properties here. If that were not so it would be incredible that something could have a single property only (compare: 'This object is just a cat but has no further properties' to 'This is a top quark').

The three alternatives will become important when I consider the next candidate for laws with exceptions which is inspired by actual physics.

Summary Candidate 1. In my attempt to lay bare the preconditions for the possibility of fundamental laws with exceptions I pointed out that there are two traps which have to be avoided. We fall into the epistemic trap if we prematurely identify law *hypotheses* with the laws. If only we knew enough we could amend the antecedent of such a hypothesis, i.e., use the right predicates or add the right circumstances to the antecedent and thereby uncover the exceptionless law. I avoided this trap by asking for rather peculiar circumstances: the exceptions to non-strict fundamental laws should happen in space-time regions which are unidentifiable in terms of general descriptions. Only by pointing at them—here: by noting down their space time coordinates—can we pick them out; with no definite description could we manage to refer to them.[17] As a reminder of these similarities to the semantics of, for example, '*I*', '*here*', and '*now*', the abbreviation 'index' or 'indexical' for 'truly ***ind***ividual ***ex***ceptional space time region' suggested itself. I claimed that the occurrence of individuals in the law candidate prevents the epistemic trap because reformulation in general terms is not possible while I also argued that we do not have to worry about the appearance of names in law statements. In a last step I offered three arguments against the possibility of assimilating index-laws to probabilistic laws. I thereby avoided the probabilistic trap. The first suggestion for a scheme for candidate laws with exceptions is thus: $\forall \mathbf{u}\ (\mathbf{Fu} \wedge \neg @(\mathbf{x, y, z, t})\mathbf{u} \supset \mathbf{Gu})$.

[17] We could try 'the spot where law L fails' but this idea does not work for two reasons: there could be more than one index and, even if there is only one, the description leads into circularities. I do not see how there could be another definite description for naked space-time regions, i.e., for spots without any further essential properties.

2.1.4 CANDIDATE 2: BLACK HOLES AND OTHER SINGULARITIES

Candidate 1 concentrated on individual exceptional space time points at which an alleged law has an exception. I have argued for the importance of the individuality of those space-time points because generally describable violations would, once explicitly excluded in the antecedent of the law, make true a different law (viz. the epistemic trap). In the light of empirical findings, I will show in what follows that the epistemic trap can be avoided by other means, i.e., we can get a kind of exception while employing purely general terms without reference to any individual in the antecedent of a law.

Candidate 2 does not spring from a philosopher's fantasies but is taken from actual physics:

> A series of theorems due principally to Stephen Hawking and Roger Penrose indicated that, according to GTR [the general theory of relativity, MAS] […] *under quite general conditions* […] [singularities] can be expected to occur both in cosmology and in the gravitational collapse of stars. (Earman 1995: 65)

A *Singularity* is a "point of infinite density and infinite curvature of space time. *All the known laws of science would break down at such a point*." (Hawking 1988: 148; my emphasis) Taken together, these two quotes claim that the general theory of relativity predicts its own failure under certain general conditions. Again, I let the experts speak:

> Einstein is surely right that, whatever the technical details of a definition of spacetime singularities, it should follow that physical laws, in so far as they presuppose space and time, are violated or, perhaps more accurately, do not make sense at singularities. (Earman 1995: 19)[18]

[18] Note aside that we can put the cart in front of the horse and take the discovery of singularities as an immense confirmation of our best physical theories: "Spacetime singularities are a feature that separates GTR from all of its predecessors Newtonian and special relativistic theories and from some of its competitor theories of gravitation.

> Penrose and I showed that general relativity predicted that time will come to an end inside a black hole. [...] But both the beginning and the end of time would be places where the equations of general relativity could not be defined. (Hawking 2001: 24)

The question I need to ask, then, is whether singularities—space-time points where "physical laws […] are violated or […] do not make sense"—can be counted as the exceptions to fundamental laws I am looking for.

Before I tackle this question I'd like to introduce yet another, and worse, kind of singularity: not only do physical theories predict their own failure at points of infinite density and infinite curvature of space-time such as in black holes, at the beginning of space and time (the big bang), and in the case of a future 'big crunch'. We also learn that if a certain hypothesis about the world, namely the *cosmic censorship hypothesis*[19] is wrong, then physics also predicts so called 'white holes' or 'naked singularities'. While their black brothers (the *clothed* singularities) just swallow up forever whatever comes too close to their neighbourhood, these white holes might, on top of that, spit out matter at random:[20]

> We should pause to contemplate a potential disaster. If the singularities that occur in Nature are naked, then chaos would seem to threaten. Since spacetime structure breaks down at singularities and since (pace Kant) physical laws presuppose space and time, it would seem that these naked singularities are sources of lawlessness. […] All sorts of nasty things—TV sets showing Nixon's "Checkers speech," green slime, Japanese horror movie monsters, etc.—emerge helter skelter from the singularity. The point can be put more formally in terms of the breakdown in predictability and determinism. (Earman

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So by confirming the existence of singularities, the theory would receive a big boost in empirical support." (Earman 1995: 224)

[19] *Cosmic censorship* is defined (a little circularly) as "the idea […] that we can cozy up to singularities without fear of being infected by the ghastly pathologies of naked singularities since GTR implies that, under reasonable conditions, Nature exercises modesty and presents us only with singularities that have been clothed in some appropriate sense." (Earman 1995: 66-7)

[20] Very recently (at the 17th International Conference on General Relativity and Gravitation, 18th - 23rd July 2004 in Dublin, Ireland) Stephen Hawking has revised his theory. He believes now that even black holes eventually spit out what they have swallowed.

1995: 65-6)[21]

Let's take stock. Physics predicts two different types of singularities, disruptive and non-disruptive ones.[22] At the heart of both, laws break down and, furthermore, the disruptive singularities (if they really exist contrary to the cosmic censorship hypothesis) even throw out random matter unsystematically. It is important to underline the word ‘unsystematically’ here for physicists tell us that white holes do not even throw up matter in any pattern which could be described in probabilistic terms:

> There are important differences between the indeterminism of QM and the indeterminism associated with a failure of cosmic censorship. In the quantum case the unitary evolution of the state vector, of which the Schrödinger equation is simply the infinitesimal form, is deterministic, and indeterminism enters only when the unitary evolution is interrupted by a miracle of a “collapse of the state vector” when a measurement is made. […] The kind of indeterminism at issue is at worst not of the anything-goes variety since the quantum theory specifies the precise form for the statistics of outcomes of quantum measurements. By contrast, the principles of classical GTR do not tell us whether a naked singularity will passively absorb whatever falls into it or will regurgitate helter-skelter TV-sets, green slime, or God only knows what. (Earman 1995: 93-94)

It seems, hence, that we have two new (closely related) candidate scenarios for laws with exceptions the second of which is truly spooky in that it could be a source of real chaos.

The Epistemic Trap. However, there is a hurdle to be passed. I insisted, when considering index-laws, that it should not be possible to exclude exceptional cases by means of general descriptions. Otherwise we could—taking these circumstances into consideration—reformulate the antecedent of the alleged law statement and thereby arrive at strict law

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[21] In their ‘Formation of Naked Singularities: The Violation of Cosmic Censorship’ Shapiro and Teukolsky indicate that general relativity does in fact allow for naked singularities (Shapiro & Teukolsky 1991).

[22] Actually, there is a whole zoo of different singularities: four main types with families of subcategories: “It will emerge that there are at least four distinct though interrelated concepts of spacetime singularities.” (Earman 1995: 27) “In short, spacetime singularities exhibit a richness and complexity unimagined by earlier pioneers of GTR.” (Earman 1995: 59) For my purposes, I can ignore this complexity.

statements. Now, in the cases of singularities the circumstances in which they occur *are* describable in general terms. So, in no case could they be subsumed under the *indices* heading: singularities do not occur at *truly individual* exceptional space-time regions.

Do we fall into the *epistemic trap*, then, if we identify singularities with exceptions to fundamental law?[23] Could certain reformulations be strictifications? Not if we make the additional assumption that, at the places where the laws fail, *no other regularities obtain*. Compare the case to index-laws. There, I introduced three options for what could happen instead at the places where the law fails (1: Chaos): the Fs either have a different further property at each index, or, (2: A Blessing in Disguise): there is a regularity within the irregularity and Fs are Hs, say, at all the indices, or, (3: Nothingness): all Fs at all indices fail to have any further property. For index-laws, (2: Blessing), the regularity within the irregularity, is acceptable without the law candidate thereby being strictified. The individuality of the exceptions weighs enough to secure the law candidate as law with exceptions.

This is not the case for laws that have their exceptions at space-time points that are describable in quite general terms. If a different regularity were true in those general circumstances C we could, next to $\forall u\ (Fu \wedge \neg Cu \supset Gu)$, easily form a second law: $\forall u\ (Fu \wedge Cu \supset Hu)$. The conjunction of the two would then be a strict meta-law. Hence, chaos at the irregularity (1: Chaos) or the total lack of a further property, (3: Nothingness) are the only chances left to subsume singularities under the exception heading. These possibilities are, luckily, also tenable. Before I point out reasons why this is so let me, however, first ask which of the three options—(1: Chaos), (2: Blessing), or (3: Nothingness)—we actually encounter in nature according to present day physics. The ultimate answer is not yet known but there are some indications. I consider each possibility in turn, starting with the unwelcome (2: Blessing):

[23] Note that I simply assume here that the general theory of relativity is true. It does, however, not matter whether it is. For my purposes it is enough if it is coherent, that is, if it is possibly true. The latter is, I believe, a reasonable assumption.

Physicists are working on a theory called *quantum gravity theory* which may supersede or, better, unite the theory of general relativity with quantum mechanics. Such a theory might provide us with an insight into what is happening inside a black hole. Were this to happen meta-laws (or simply new laws) could be formed which tell us both what happens outside and inside black holes. In that case, general relativity together with singularities would no longer be good candidate for laws with exceptions; general relativity would be a premature hypothesis. Therefore, if we were to declare general relativity to be a candidate theory for laws with exceptions we would, indeed, fall into the *epistemic trap*; the unwelcome result I have predicted for possibility (2: Blessing).

Hence, we must hope for the other two options and, in fact, if general relativity is the last and accurate word about our world then (3: Nothingness) is the right description for black holes and (1: Chaos) for white holes. I come first to black holes and (3: Nothingness). We have to have a closer look at the respective actual law statements to fully understand what is going on. Philosophers' laws like $\forall x(Fx \supset Gx)$ are often oversimplifications and therefore hide crucial features. They do not, for example, capture the fact that scientific laws often have a functional structure of the kind $f(x)=y$. It is only when we look at these functions that we can fully understand Earman's and Hawking's claims:

> Physical laws […] do not make sense at singularities. (Earman 1995: 19)

And

> [Black holes] would be places where the equations of general relativity could not be defined. (Hawking 2001: 24)
>
> One might suppose that there were new laws that held at singularities, but it would be very difficult even to formulate such laws at such badly behaved points, and we would have no guide from observations as to what those laws might be. (Hawking 1988: 148)

Take, for example, the function f(x)=1/x. It is not defined for x=0 but rushes off to infinity when x approaches 0. Mathematicians call these points of a function 'singularities' and it is from the mathematicians that the physicists adopted this term. In the infinity case, like above, the singularity is called a pole. There are three other kinds of mathematical singularities.[24] Yet, the poles are the ones which matter. The reason is simple: the physical singularities Earman and Hawking talk about are precisely the poles the equations of general relativity have.[25] In short, some of the law statements of our best present scientific theories have mathematical poles, but if these law statements are true and everything there is to say about the universe, then black holes—the physical correspondence of these undefined points—are space-time regions where the laws break down and *nothingness* triumphs. Black holes, therefore, can be categorised under classification (3: Nothingness).

So far so good but why do they not fall into the epistemic trap? The reason is hidden in two features of the general laws under concern and their breakdowns. First, consider the fact that the failures of these laws are *inbuilt*:

> Indeed, if cosmic censorship fails for GTR, then it would seem that classical GTR is convicted out of its own mouth of the sin of incompleteness. (Earman 1995: 225)

Unlike index-laws, for which breakdowns at indices come from the outside and as a surprise, singularities are built into the mathematical formulae. Secondly, if (3: Nothingness) is the case, the gaps can not be filled with alternatives. I suggest, therefore, that both the fact that breakdown points are self-inflicted and that there's a lack of alternatives disarm the epistemic trap: there are no meta-laws to be found which would relegate general relativity to the level of premature hypotheses.

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[24] The others are classified as *removable singularities* (those where we could simply add the missing point and make the function complete), *essential singularities* (which are defined as being neither removable nor poles), and *branch points*.

[25] Physical equations seem not to have any of the other singularities mentioned in the previous footnote. However, the *essential singularities* would be an interesting species from the perspective of exceptions if they were to exist in physical formulae for they would manifest unbridgeable gaps.

I now come to white holes. As mentioned earlier, white holes might cause chaos. Yet, not quite in the way I described theoretically above. The difference is that I demand in (1: Chaos) that chaos rules at the very point where the laws break down. White holes, however, are as silent at these points as black holes (so, on these grounds we can already categorise them under (3: Nothingness) and are off the epistemic hook). It is rather *the environment* of white holes which could be chaotic because it could be polluted with arbitrary material objects spat out at random. Remember Earman's quote:

> It would seem that these naked singularities are sources of lawlessness. […] All sort of nasty things—TV sets showing Nixon's "Checkers speech", green slime, Japanese horror movie monsters, etc.—emerge helter skelter from the singularity. (Earman 1995: 65-6)

If naked singularities happen to exist, the hope would be, of course, that new laws about the monsters they spit out could be discovered but if not we have a strong candidate for real exceptions that do not fall into the epistemic trap. Earman comments:

> Must we conclude that physics becomes hopeless? No! We can try to discern what regularities naked singularities display. For example, are the singularities that develop in certain situations quiescent? Do those that develop in other situations all ooze green slime, and if so do they ooze it at a regular rate? The attitude that physics is hopeless if naked singularities occur stems from what may be termed GTR chauvinism—the notion that Einstein and his followers discovered all of the laws relevant to classical gravitation. If we acknowledge that laws of nature are simply codifications of certain deep regularities, then we should be prepared to discover through observation that naked singularities obey laws of their own. If we are lucky these additional laws, when conjoined with the laws of standard GTR, will restore predictability and determinism. Even if we are not so lucky they may still give us some interesting physics. Of course, we must be prepared for the eventuality that naked singularities exhibit no interesting regularities at all, in which case they would indeed be a disaster for physics. But at present only GTR chauvinism would lead us to fixate on this worst-case scenario. (Earman 1995: 97)

Now, if we should discover new laws about what emerges out of white holes after all, we would not have a chaos scenario similar to (1: Chaos) but we would still have the nothingness at the very point where the singularity is placed (3: Nothingness) and, so, we would still avoid the epistemic trap as already shown for the case of black holes. Should there even be no new laws for the surroundings of white holes we have two reasons why the epistemic trap is avoided. Consequently, for both singularities—black and, *a fortiori*, white holes—the epistemic trap is no danger.

The Probabilistic Trap. I turn to the probabilistic trap but I can deal with it relatively quickly for the following reason: the laws considered predict their own failure *as a matter of certainty* and this is all there is to say. (In the case of white holes their spitting out of random matter could turn out to be covered by probabilistic laws but this is a different matter. It would not, thereby, make the occurrence of the white hole probabilistic).

Summary. Next to indices (Candidate 1), I have introduced phenomena from actual physics (Candidate 2)—black holes and, if they really exist, white holes—which could qualify as exceptions to the laws. I have argued that neither Candidate 1 nor Candidate 2 falls into the epistemic or the probabilistic trap.

2.1.5 FOUR GENERAL REMARKS ON INDICES AND SINGULARITIES

I have four general remarks on the two candidates. First, I would like to draw attention to two differences between singularities (Candidate 2) and index laws (Candidate 1). At singularities the laws of general relativity not only fail, they do not even have an answer for *what would happen if they did not fail* since their failing is a matter of being undefined. In other words, while an *index*-law like $\forall u\ (Fu \wedge \neg @(x, y, z, t)u \supset Gu)$ allows for the counterfactual conditional 'If, at (x, y, z, t), things were as they are in all other places at all times then, also at (x, y, z, t), an F would be a G' the peculiarity about singularities is that no such counterfactual conditional would be supported. What could we say, counterfactually, about y's value at x=0 for y=1/x?[26] A second difference between indices and singularities is that singularities can come into existence and we can predict and observe their genesis. I do not know, however, what philosophical implication this difference has.

Note, secondly, that there could, of course, be other candidates apart from singularities and indices; maybe even of an altogether different kind. While I do not claim completeness I do, however, claim to have enough material: I have offered two ways in which fundamental laws could have exceptions and I can turn, in the next chapters, to general theories of lawhood and assess whether they can accommodate these candidates.

I have a third remark on the consequences the existence of fundamental laws with exceptions would have. Our concepts of laws, properties, natural necessity, causation, and counterfactual conditionals hang together. If you change your theory of one of these entities you will, most likely, have to adjust your theories of the others. It is, for example, particularly striking that the way to describe the index scenarios has to be different if one does not allow properties to be instantiated without their laws and believes that every property is itself dispositional or is essentially linked to dispositions. For example, one would have to say that a massive particle turns into something else when it moves into a non-gravity index—something without mass but with something similar that does not make it attract other masses.[27]

A final consequence is a welcome one for my later chapters on non-fundamental laws about complex objects. I will concluded there that one way for those laws to have exceptions is when underlying laws have exceptions. Now, we can imagine quite vividly what would happen to complex objects when they either moved into an index or a singularity. No doubt, the non-fundamental laws about these objects would fail together

[26] This feature would be especially striking if physical formulae could also have *essential singularities*.

[27] I regret not having had more time to discuss laws and exceptions also within the framework of essentialists' metaphysics where (some) laws are supposed to hold with metaphysical necessity. See, for example, Brian Ellis's *Scientific Essentialism* (Ellis 2001) or his *The Philosophy of Nature* (Ellis 2002).

with the laws about the objects' parts and their substructure. (This remark will be clearer in the light of chapter 3.2)

2.1.6 FUNDAMENTAL PROBABILISTIC LAWS WITH EXCEPTIONS?

I warned of the probabilistic trap into which one could fall whilst hunting for candidates of laws with exceptions: a law which looks as if it has exceptions could, in reality, just be a genuine probabilistic law. With singularities and indices I hope to have escaped this trap. Now, I turn to quite a different question: are there genuine probabilistic laws with exceptions? This question is particularly difficult for the reason that it is not immediately clear what a violation of a probabilistic law would be. To start with, the event $F \wedge \neg G$ is certainly not a violation of the law $p(G|F)=r$ however high r is (as long as $r<1$). Rather, a violation would occur if, at certain space time region (x, y, z, t), $p(G|F)$ would be r* as opposed to r (with $r^* \neq r$).

There is a metaphysical and an epistemic problem with this possibility. The epistemic problem is that even if we can make sense of this possibility metaphysically it could be almost impossible for us to find out if it has occurred. We have to keep in mind that we are not just dealing with derived probabilistic laws whose probability can be influenced by altering the background conditions but with genuine ones where there is nothing (no underlying mechanism, no background conditions) that could indicate the change in probability. We can just count the F-instances that are also G-instances. I want to leave this epistemic aspect aside and exclusively turn to metaphysics.

Here, we have two possible paths to follow. If we believe in objective propensities/chances we can easily make sense of the changes of r. We can translate the probabilistic law $p(G|F)=r$ into $\forall x\ (Fx \supset PG_r(x))$, that is, into a law statement which says that if an x is F it also has the objective chance

PG of value r to become G. This formulation enables us to apply the considerations for candidate 1 straightforwardly: there could be *indices* at which Fs do not have PG_r but PG_{r*}.[28]

If, however, we do not believe in objective chance and see probabilities as derivatives of frequencies it is far from clear how to deal with this case. I want to leave it an open question for now. Some more light will be shed on probability without propensities when I discuss Lewis's characterisation of lawhood, including his theory of probabilistic laws (cf. chapter 2.2.5).

2.1.7 SUMMARY

In this chapter I studied how we could, in principle, conceive of fundamental laws with exceptions. I warned of two traps: we must neither identify premature law hypotheses with laws—this is tempting because good but not perfect conjectures have exceptions—nor should we mistake genuine probabilistic laws for laws with exceptions—this is easily done as both probabilistic laws and laws with exceptions have in common that they sometimes fail to deliver.

I have introduced two candidates of laws with exceptions and I have argued that they avoid the two traps. The first candidate, index laws, is my invention whereas the second, laws with singularities, is a well known phenomenon of actual physics.

Yet, there is still some work to be done for, so far, I have simply assumed that my candidate laws are worthy of the title of 'laws'. Whether they are so remains to be seen. To do so, I must consider how these candidates fit into general theories of lawhood. This is the task of the next two chapters where I examine David Lewis's and David Armstrong's theory of lawhood (chapter 2.2 and, respectively, chapter 2.3). Beforehand, however, I turn briefly to an issue from philosophy of religion which is

[28] Undeniably, it would be extremely difficult (if not impossible) to discover this.

very closely related to the topic of laws with exceptions.

2.1.8 EXCURSUS: MIRACLES

The aim of this excursus is modest. I just want to point out that my central question—whether there is a tenable concept of laws of nature that could allow for exceptions to these laws—has been discussed in philosophy of religion and theology (although neglected by philosophy of science). In fact, some of the ideas which have been put forward in these areas resemble the theses about exceptions I have presented in sections on indices.

Amongst most philosophers of religion and theologians there is consensus that a miracle is to be characterised as a violation of a law of nature (or the laws of nature) due to an act of God (or of the Gods).[29] Let us hear Swinburne and Hume:

> I understand by a miracle a violation of a law of Nature by a God, that is, a very powerful rational being who is not a material object […]. My definition of a miracle is thus approximately the same as Hume's: "a transgression of a law of nature by a particular volition of the Deity or by the interposition of some invisible agent". (Swinburne 1968: 320; the Hume quote within this quote is from Hume's *Enquiry Concerning Human Understanding* (Hume 1777: 115, fn. 1))

Even *The Oxford Dictionary of Physics*, in its entry on "Laws, theories and hypotheses", brings the two topics—miracles and exceptions to fundamental laws—together:

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[29] This definition aims to be an ontological definition of miracles. Some philosophers, like Locke in his short *A Discourse on Miracles*, have offered characterisations *relativised to epistemic subjects*: "A miracle then I take to be a sensible operation, which, being *above the comprehension of the spectator*, and in his opinion contrary to the established course of nature, is taken by him to be divine." (Locke 1709: 79; my italics) "Hereby what is a miracle is made very uncertain; for it depending on the opinion of the spectator, that will be a miracle to one which will not be so to another." (Locke 1709: 80).

> There are no loopholes in the laws of nature and any exceptional event that did not comply with the law would require the existing law to be discarded or would have to be described as a miracle. (Isaacs 2000: 260)

I take it, then, that we can write down the following equation:

> miracles = exceptions to laws of nature with a supernatural cause[30]

If this is a correct characterisation, a look at the arguments which have been put forward by theologians and philosophers of religion for the possibility of miracles can enlighten or support what I have said about the metaphysical possibility of exceptions. I will now dare this religious excursus.[31]

The fundamental tension between the concept of a miracle and the concept of a law is this: if a miracle is defined as an exception to a law but the concept of law entails that laws are strictly universal regularities then there cannot be any miracles by definition. Note that, even if there were no universal regularities in nature, there still wouldn't be any miracles because there would not be any laws either (cf. Mackie 1982: 19). The conclusion is straightforward: if we want both miracles and laws we either have to change the concept of a miracle (i) or the concept of a law (ii).

I turn briefly to (i): We could, for example, define a miracle in an epistemic way as an act of a God which comes as *an unexpected surprise* as, for example, John Locke did in his *A Discourse on Miracles* (Locke 1709; see my footnote 29). I will, however, disregard this epistemic option for the simple reason that my topic is *the metaphysics of laws with exceptions*.

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[30] That is, if an exception to a law is, as a matter of fact, caused by a God, it should be called a miracle. (Unless, maybe, the God caused the exception unintentionally and by mistake. However, one might ask scholastically: 'Could Gods act unintentionally?')

[31] I will disregard the reference to God or any other supernatural agent and leave specifically religious arguments aside in these considerations. Note, however, that some theists take already the simple occurrence of an exception to a law to be a hint at the existence of God. Their Bayesian motivated argument is this: given the fact that our world is law governed, the probability of the occurrence of a violation of those laws is higher if we presuppose the existence of God than its probability without this presupposition (cf. Swinburne 1979: 66-72).

As a consequence also Hume's famous argumentation in *On Miracles* (Hume 1777: 109-132) which focuses on testimony and evidence is not of primary interest to me. Let me point out, however, that it is an interesting speculation whether we can conclude from the fact that Hume puts forward an epistemic argument against miracles that he has accepted the in principle existence, i.e., their *conceptual possibility*, already.[32] Two opposing interpretations spring to mind: (a) he thinks the epistemic argument is interesting in its own right and he puts it forward to establish the implicit preliminary note that even if miracles existed you would not be able to find them or (b) his argument is in the line of a strong verificationism: if, in principle, you can't detect them miracles do not exist.[33]

In any case, I must turn to (ii): the metaphysical question whether we can change our concept of a law in such a way that miracles become at least conceptually possible. It is here where I can find support for my own enterprise.

One suggestion comes from Richard Swinburne. As his starting point, he underlines that miraculous events have essentially to be one-off events:

> It seems natural to understand […] by a violation of a law of nature, an occurrence of a non-repeatable counter-instance to a law of nature. […] If we have good reasons to believe that an event E has occurred contrary to predictions of a formula L which we have good reasons to believe to be a law of nature, and we have good reason to believe that events similar to E would not occur in circumstances as similar as we like in any respect to those of the original occurrence, then we do not have reason to believe that L is not a law of nature. For any modified formula which allowed us to predict E would allow us to predict similar events in similar circumstances and hence, we have good reasons to believe, would give false predictions. Whereas if we leave the formula L unmodified, it will, we have good reasons to believe, give correct predictions in all other conceivable circumstances. Hence if we are to say that any law of nature is operative in the fields in

[32] This claim is supported by, e.g., the following quotes: "A miracle is a violation of the laws of nature." (Hume 1777: 114) and "A miracle may either be discoverable by men or not. This alters not its nature and essence." (Hume 1777: 115; fn. 1)
[33] Or Hume's argument is overall an "abject failure" as John Earman has argued in (Earman 2000).

> question we must say that it is L. This seems a natural thing to say rather than to say that no law of nature operates in the field. (Swinburne 1968: 320-1)

Swinburne's paragraph is, I think, the epistemologically impregnated[34] short version of my story about *indices*. Swinburne, however, already incorporates a line of thought I aim to supply only in the next two chapters when discussing how my suggestions about law candidates with exceptions fare in standard theories of lawhood (Lewis and Armstrong). Swinburne says, without delivering further arguments, that it seems a natural thing to say that the law is still a law while being violated rather 'than to say that no law of nature operates in the field'. While I will eventually agree with him I see the need for further argumentation.

Note aside that, in a passage I have left out above, Swinburne sketches what I have called the *epistemic trap*:

> Clearly, as Hume admitted, events contrary to predictions of formulae which we had good reasons to believe to be laws of nature often occur. But if we have good reasons to believe that they have occurred and good reasons to believe that similar events would occur in similar circumstances, then we have good reasons to believe that the formulae which we previously believed to be the laws of nature were not in fact such laws. Repeatable counter-instances do not violate laws of nature, they just show propositions purporting to state laws of nature to be false. (Swinburne 1968: 320)

Another suggestion about how to think of miracles is inspired by John Mackie. He shifts attention from the violation of any random law to the violation of a special kind of law: the fundamental conservation principles. Miracles, he points out, could be understood as supernatural forces or impulses (the 'Hand of God', so to speak) which operate now and then next to the fundamental forces between elementary particles. Only the conservation laws would be violated by the occurrence of these forces but not the individual force laws, like Newton's law of gravitation, Coulomb's law, etc. Note that this kind of violation is not an essentially new idea next to the *index* idea, though. It only singles out a particular kind of law which is violated at the indices as well as a way in which the violation is done.

[34] I say this because he repeatedly inserts epistemic caveats: "…we have good reasons to believe…".

This concludes my brief excursus concerning miracles. I admit that no new insights into divine spheres are gained from it. Yet, I believe that it confirms nicely that the idea of fundamental laws with exceptions (here *indices*) is not dismissed by everyone as completely outrageous. A final remark: my excursus focussed on index laws and their relation to miracles. Needles to say, there is an abundance of religious, esoteric, and science fiction interpretations of black holes, the big bang, white holes, etc. Some of these stories locate God, the Creator, or other supernatural forces at the heart of these phenomena. The lack of laws seems to be a magnet for mystical speculations.

2.2
FUNDAMENTAL LAWS: DAVID LEWIS

2.2.1
INTRODUCTION

In this chapter I aim to assess whether there is conceptual space for laws with exceptions against the background of Lewis's characterisation of lawhood. The short answer which will later prove to be too superficial is a straight ‘No!’:

> Few would deny that laws of nature, whatever else they might be, are at least exceptionless regularities. (Lewis 1986: xi)

> Admittedly, we do speak of defeasible laws, laws with exceptions, and so forth. But these, I take it, are rough-and-ready approximations to the real laws. There [sic!] real laws have no exceptions, and never had any chance of having any. (Lewis 1980: 125)

Judging by these quotes it seems that, for Lewis, each and every exception would catapult an alleged law out of the realm of candidates for lawhood. But the textual exegesis is incomplete. In later passages of *Counterfactuals* we find:

> A localized violation is not the most serious sort of difference of law. The violated deterministic law [in a close-by world; MAS] has presumably not been replaced by a contrary law. Indeed, *a version of the violated law, complicated and weakened by a clause to permit the one exception, may still be simple and strong enough to survive as a law*. (Lewis 1973: 75; my italics)

I will show, in this chapter, that there is, in fact, the possibility of a Lewisean concept of lawhood which allows for exceptions. In order to achieve this aim I first need to outline his general theory of lawhood.

2.2.2 THE (MILL-)RAMSEY-LEWIS INTERPRETATION OF LAWHOOD

Lewis's theory of laws of nature first appears in his book *Counterfactuals* (Lewis 1973). He—like Frank Ramsey (whom he quotes)—believes

> that laws are 'consequences of those propositions which we should take as axioms if we knew everything and organized it as simply as possible in a deductive system'. (Lewis 1973: 73)[1]

Lewis elaborates on Ramsey's view: there exist innumerable true *deductive systems*, i.e., *deductively closed, axiomatisable sets of true sentences*. Some are axiomatised more *simply*, some are *stronger*, i.e., some have more informational content. Simplicity and strength can be in conflict, but "what we value in a deductive system is a properly balanced combination of simplicity and strength as much of both as truth and our way of balancing will permit." (Lewis 1973: 73) Lewis's re-formulation of Ramsey, hence, is:

> A contingent generalization is a *law of nature* if and only if it appears as a theorem (or axiom) in each of the true deductive systems that achieves a best combination of simplicity and strength (Fn.: I doubt that our standards of simplicity would permit an infinite ascent of better and better systems; but if they do, we should say that a law must appear as a theorem in all sufficiently good true systems). A generalisation is a law at a world *i*, likewise, if and only if it appears as a theorem in each of the best deductive systems true at *i*. (Lewis 1973: 73)

A brief digression on John Stuart Mill. People generally include a third philosopher when they speak of the theory of lawhood now under

[1] Note that Ramsey does not speak "of those *universal* propositions which…". Maybe Ramsey allows for less than universal statements? In any case it is worth mentioning that Ramsey held the view quoted above only temporarily. Later, he subscribed to the view that law statements are prescriptive rather than descriptive in the sense that they give us "not judgments but rules for judging 'If I meet a φ I shall regard it as a ψ'" (Ramsey 1990: 149).

inspection: John Stuart Mill's view seems to be a precursor of Lewis and Ramsey (cf. Lewis 1983: 41; also fn. 27 on that page). This is what Mill writes:

> According to one mode of expression, the question, What are laws of nature? may be stated thus:—*What are the fewest and simplest assumptions, which being granted, the whole existing order of nature would result?* Another mode of stating the question would be thus: *What are the fewest general propositions from which all uniformities which exist in the universe might be deductively inferred?* (Mill 1843: 317; my emphasis)[2]

However, it must be mentioned that Mill claims explicitly that the basic uniformities, i.e., those which belong "to the fewest and simplest assumptions, which being granted, the whole existing order of nature would result" are about *tendencies*, *natures*, or *dispositions* and not about actually occurring regularities:

> These facts are correctly indicated by the expression *tendency*. All laws of causation, in consequence of their liability to be counteracted, require to be stated in words affirmative of tendencies only, not of actual results. (Mill 1943: 445)

The consequence is that anti-Humean dispositionalists (and, hence, anti-Lewiseans), like Nancy Cartwright, also claim Mill for themselves. For this reason, I hesitate to speak of the *Mill*-Ramsey-Lewis view.

Holism. Returning to my brief summary of Lewis's theory, lawhood is, in his system, not just the generality (syntactical or semantic) of a single sentence. His holistic approach solves, therefore, Reichenbach's riddle of how to distinguish laws from accidental generalisations when the two statements are syntactically and semantically alike. Remember:

1. All solid spheres of enriched uranium (U235) have a diameter of less than one mile.
2. All solid spheres of gold (Au) have a diameter of less than one mile.

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[2] Lewis (in Lewis 1983: 41; fn. 27) does not quote Mill, but gives the following (correct) reference: "John Stuart Mill, *A System of Logic* (Parker, 1843) Book III, Chapter IV, Section 1".

Accidental general statements are those which are not included in the simplest and strongest system and it is justified to suppose that the second generalisation (the gold spheres one) would not belong to that system.

I mention this holistic feature of Lewis's system because it will turn out to be extremely helpful to my enterprise. Lewis's thought is this: generality of a sentence is not in itself enough, but hopefully generality plus membership in the best system is. The thought I will develop later (and which I have already briefly introduced in a part of chapter 2.1.1, called ‘An Appetiser’) is: maybe generality plus membership in the best system is even more than we need. Maybe something only close to generality plus membership in the best system is adequate enough for lawhood. That would, as I will argue, allow laws to have exceptions. In other words, the additional support for the pure generality of a statement that we need in order to distinguish accidental generalisations from laws, and that we get from best system membership, might do more than just fill in that gap: it might allow us to subtract from generality. I will come back to this crucial matter later.

After the prototype in *Counterfactuals* Lewis was forced to add some extra features to the nucleus of his theory. (i) Some of these concern probabilistic laws; (ii) others concern the language in which the law statements of the best system has to be phrased. Finally, (iii), his recommendation for how to manage possible ties between good systems changes. I will briefly describe those changes in turn.

(i): The way in which Lewis treats chance laws (and chances themselves)[3] is this: take systems of law candidates, including those that

[3] It took Lewis a while to find the right account (in his opinion) to deal with chance laws. In ‘A Subjectivist's Guide to Objective Chance’ (Lewis 1980), where Lewis introduces the *Principal Principle* linking credence to chance, he dealt for the first time with genuinely probabilistic laws. There, however, he had not yet found a satisfactory way to handle them. This is essentially due to the fact that it seemed to him at that time (and much to his despair) that he would have to accept an anti-Humean interpretation of objective chances. That, however, would have counted against his strong belief in *Humean Supervenience*. It was Michael Thau who later provided him with a new interpretation of the *Principal Principle* which made, according to Lewis, a Humean interpretation of chances possible (cf. Thau 1994). As a

talk about the chances of events happening.

> Consider deductive systems that pertain not only to what happens in history, but to what the chances are of various outcomes in various situations—for instance, the decay probabilities for atoms of various isotopes. […] Some will say either what will happen or what the chances will be when situations of a certain kind arise, whereas others will fall silent both about the outcomes and about the chances. And further, some will fit the actual outcomes and the history better than others. That is, the chance of that course of history will be higher according to some systems than according to others. […] The virtues of simplicity, strength, and fit trade off. The best system is the system that gets best balance of all three. As before, the laws are those regularities that are theorems of the best system. But now some of the laws are probabilistic. So now we can analyse chance: the chances are what the probabilistic laws of the best system say they are. (Lewis 1994: 234)[4]

(ii): In his 'New Work for a Theory of Universals' Lewis adds restrictions to the language in which laws have to be formulated. He admits *perfectly natural properties* into his ontology and concludes that the "primitive vocabulary that appears in the axioms [of the best system; MAS] refer[s] only to perfectly natural properties" (Lewis 1983: 42). The reason for this move is, roughly, that if *any* language (containing absurd *gruesome* predicates) were allowed for the candidate systems comparisons between these systems regarding their simplicity would be impossible. Note aside that Lewis believes that natural properties and laws are discovered together (cf. Lewis 1983: 43).

(iii): A final change in Lewis's theory of lawhood concerns the character or status of the best system. Were there to be two or more very

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result, Lewis could restore *Humean Supervenience* in '*Humean Supervenience* Debugged' (Lewis 1994) and he also gave a more adequate formulation of his characterisation of lawhood which includes probabilistic laws.

[4] The formulation "The best system is the system that gets best balance of all three" is a bit unfortunate. A very weak, complicated and unfit system could still *balance* its simplicity, strength, and fit best. Balance has to be thrown into the collection of criteria on top and not only as summary of simplicity, strength, and fit. This is also what Lewis suggests himself in '*Humean Supervenience* Debugged': "If nature is kind, the best system will *robustly* be the best—so far ahead of its rivals that it will come out first under any standards of simplicity and strength *and balance*." (Lewis 1994: 233; the second italics are mine)

good systems, no one of which was strictly better than the other, then Lewis envisaged that "a law is any regularity that earns inclusion in the ideal system. (Or, *in case of ties*, in every ideal system.)" (Lewis 1983: 41; my emphasis) Later he became more demanding:

> If nature is kind, the best system will *robustly* be the best—so far ahead of its rivals that it will come out first under any standards of simplicity and strength and balance. We have no guarantee that nature is kind in this way, but no evidence that it isn't. It's a reasonable hope. Perhaps we presuppose it in our thinking about law. [...] I can admit that *if* nature were unkind [...] then lawhood might be a psychological matter. [...] But I'd blame the trouble on unkind nature, not on the analysis. (Lewis 1994: 233)[5]

Consequently, fewer worlds will have the honour of being law governed: only those with robustly best systems and not also those with ties.

Summarising Lewis's position, a contingent generalisation is a law of nature if and only if it appears as an axiom or theorem in the true deductive system which fulfils the following two requirements uniquely: (1) its primitive vocabulary refers only to perfectly natural properties, (2) it balances simplicity, strength, and fit robustly better than any other system; where

> - to have *strength* is to bear a great deal of informational content about the world;
>
> - to be *simple* is not being redundant, to state everything in a concise way, etc.;
>
> - to *fit* is (especially for the probabilistic laws) to accord, as much as possible, with the actual outcomes of world history.

[5] The quote is, by the way, also directed against the allegation that Lewis's criteria—strength, simplicity, fit, and balance—are mere products of human psychology so that his laws will be something human made (or based). It is important for my own inquiry that Lewis's theory is a realist theory. The full quote is: "The worst problem about the best system analysis is that when we ask where the standards of simplicity and strength and balance come from, the answer may seem to be that they come from us. [...] The real answer lies elsewhere: if nature is kind to us, the problem needn't arise. I suppose our standards of simplicity and strength and balance are only partly a matter of psychology. [...] not anything goes. If nature is kind, the best system will be robustly best…" (Lewis 1994: 232-3)

2.2.3 ARE FUNDAMENTAL LAWS WITH EXCEPTIONS POSSIBLE?

In this section I will present arguments for why I think it is possible for Lewis to accept fundamental laws with exceptions of the two kinds I have characterised in the previous chapter. That is, I will argue that a law candidate like $\forall u\ (Fu \wedge \neg @(x, y, z, t)u \supset Gu)$ and also laws with singularities can be part of a best system.[6] I will, however, also raise some doubts.

2.2.3.1 SINGULARITIES (CANDIDATE 2)

First I turn to the singularities family (Candidate 2). It is possible to deal with them rather quickly. Remember that what happens inside black holes remains a mystery (worse if white holes spit out matter without any law saying when and what kind of matter). Now, a system of laws that includes the general theory of relativity (whose laws predict their own breakdown at certain points) has a small minus on its strength side because it does not describe *everything* in the world: it leaves out what happens at singularities.

However, that does not tell us anything about its *relative* strength compared to other systems. And this is what matters. We just have to suppose that no other system of prospective laws has a better overall balance of strength, simplicity, and fit. That is, if a black-holes-friendly system still comes out as the robustly best system although it has little weaknesses now and then no major harm has been done to its competition

[6] Note that any philosophical theory of lawhood had better be able to cope with singularities like black holes for if it cannot deal with what our best physical theories predict it has to be dismissed as empirically inadequate.

fitness by the occasional black hole.[7] It is the overall performance that counts. Once more the holistic character of Lewis's theory does a great job. Holism is a strong safety net; laws survive even when little gaps occur.

Note aside that some physicist contend that the question ‘what happens in the heart of a black hole?’ is meaningless (analogous: ‘what happened before the big bang?’). The centre of a singularity, so proponents of this position argue, is simply not a part of the universe and so no information is lost if a theory keeps quiet about what happens at these places. If this is correct there is little to no impact on my argument. Then systems which contain the general theory of relativity are not weakened by the existence of black holes at all and are competing with other systems without any handicap.

The conclusion of all this is straightforward: Lewis’s theory can easily cope with Candidate 2 for laws with exceptions.

2.2.3.2
INDICES (CANDIDATE 1)

I will now turn to candidate 1, the index-laws. The main argument for the lawlike status of these candidates comes from counterfactual reasoning. Metaphysical considerations about *Humean Supervenience* will later support the argument. I will also compare my findings with those of Braddon-Mitchell in his ‘Lossy Laws’ (Braddon-Mitchell 2001).

(1) An Argument from Counterfactual reasoning. Lewis's theory of counterfactual conditionals is couched in terms of possible worlds and relies heavily on similarity relations between those possible worlds. Lewis does not, however, attribute a special status to the laws of nature in similarity considerations. While two worlds which have the same laws certainly have a good deal in common it is by no means a necessary condition for worlds to share laws in order to be judged similar.

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[7] Again: this is supposing that there is no system including a functioning theory of quantum gravitation which does include information about the heart of black holes.

> I could, if I wished, incorporate [a] special status of laws into my theory by imposing the following constraint on the system of spheres: […] whenever the laws prevailing at i are violated at a world k but not at a world j, j is closer than k to i. This would mean that any violating of the laws of i, however slight, would outweigh any amount of difference from i in respect of particular states of affairs. I have not chosen to impose any such constraint. (Lewis 1973: 72-3)[8]

This is already a promising remark which loosens up the rigidity of laws. However, we are only half way on the path towards a notion of laws that allows for exceptions. This is because

> the violated laws are not laws of the same world where they are violated. […] I am using 'miracle' [i.e., violation of law; MAS] to express a relation between different worlds. A miracle at w_1, relative to w_0, is a violation at w_1 of the laws of w_0, which are *at best the almost-laws of* w_1. The laws of w_1 itself, if such there be, do not enter into it. (Lewis 1979: 44-45; my italics)

What I need, however, is a violation of laws *at home*, i.e., at w_0 itself. I have omitted from the quote just given the rather discouraging statement: “This is impossible; whatever else a law may be, it is at least an exceptionless regularity” (Lewis 1979: 44-45). Yet, as I announced at the beginning of this chapter, we also find more supportive quotes. Here is a beginning:

> A localized violation is not the most serious sort of difference of law. The violated deterministic law has presumably not been replaced by a contrary law. Indeed, a version of the violated law, complicated and weakened by a clause to permit the one exception, may still be simple and strong enough *to survive as a law*. (Lewis 1973: 75; my italics)

Needless to say, it all depends on how extended the violation is: if it is temporally and spatially very limited, merely “a small, localized, inconspicuous miracle” (Lewis 1973: 75), then it is easy to imagine that

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[8] Later, in (Lewis 1979) he promotes the status of laws a little. However, having the same exceptionless laws is, though of first importance, still no *necessary* condition for similarity amongst worlds: “It is of the first importance to avoid big, widespread, diverse violation of law.” (Lewis 1979: 47)

the loss of simplicity, strength and fit[9] we have to accept when we "complicate and weaken" the law by a clause, still does not affect the robustly best position of the system that includes that law. That is, no other system would thereby become a robustly better system (nor would other systems become equally good such that a draw results). Therefore, the law status of a law, i.e., its membership in the best system, would be saved even if it has little exceptions.

The more laws (in an alleged best system) are affected by exceptions, or the more extended the space-time area is in which violations happen, the less likely it will be that this system is in fact the best or, indeed, that there is any such best system. Yet, about that fact we do not have to worry too much because it comes down to saying that the more messy the world is the less likely it is that it is law governed. This has never been subject to doubt.

A closer look at the quote from above reveals that Lewis allows precisely the kind of laws with exceptions I have introduced under the name *index-laws*: "the violated law, complicated and weakened by a clause to permit the one exception" sounds very much like what '∀u (Fu ∧ ¬@(x, y, z, t)u ⊃ Gu)' says.

This brings my assessment of Lewis's best system laws almost to a conclusion. The answer to the question whether he can or, in fact, *does* allow laws with exceptions (here: index-laws), is 'Yes'. Yet, there is even a further argument in favour of the acceptance of exceptions:

(2) An Argument from Metaphysical Considerations about *Humean Supervenience*. A doctrine Lewis calls "Humean Supervenience" says that the world is nothing but "a vast mosaic of local matters of particular fact, just one little thing and then another" (Lewis 1986: ix). Everything else—laws of nature, counterfactuals, causation, persistence through time, chance, mind and language (cf. Lewis 1986: xi-xiv)—supervenes on this mosaic. An important part of *Humean Supervenience* is

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[9] Note that a law like ∀u (Fu ∧ ¬@(x, y, z, t)u ⊃ Gu) is, because of the additional part ¬@(x, y, z, t)u, not only less simple than ∀u (Fu ⊃ Gu), it also loses strength: it does not tell us what happens at (x, y, z, t).

the unconnectedness of these local matters of particular fact. In the words of Hume himself this claim reads:

> no objects have any discoverable connexion together, and that all the inferences, which we can draw from one to another, are founded merely on our experience of their constant and regular conjunction in our world. (Hume 1777: 111)

In this section, I want to point out that exceptions to regularities should not come as a shock for a metaphysical doctrine like *Humean Supervenience*. Exceptions might surprise our custom and habit formed expectations. On rational reflection, however, it should be considered as rather unlikely that the mosaic of local matters of particular fact is a completely orderly pattern without any odd fact here and there. If there is no connexion in nature a violation of a regular pattern is nothing but a violation of expectation; not, however, a violation of any natural phenomenon.[10]

To put it in other words, in Lewis's universe of possible worlds there are countless ones which are just like ours except for this one little miracle. What tells us that our world *is* none of those worlds? In fact, wouldn't it be as likely that we ended up existing in one of those rather than in our, supposedly orderly world? (I pity our poor counterparts who have already encountered a few of those 'miracles'. I bet they are strong believers in ghosts and other supernatural occurrences. In fact, their beliefs would not be completely unjustified!)

What are these remarks good for? They ease the pain the acceptance of irregular events could cause. Indeed, if you have already accepted *Humean Supervenience* it should be no great deal for you to expect an oddity here and there. Now, this does, of course, not automatically mean that Humeans can accept laws with exceptions. One can hold both views: (i) that nature is

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[10] In the light of this consideration it is questionable whether Hume is right to claim that the event of a miracle is independent from any observer: "A miracle may either be discoverable by men or not. This alters not its nature and essence." (Hume Enquiries 1777: 115; footnote 1) (See also my 2.1.8. on miracles.) If custom and habit of epistemic subjects are the only ties which can be broken by a miracle then miracles are, in this sense, not independent of the discovery of men. In a Hume world a miracle should be seen as something quite natural.

irregular and that laws are strict with the consequence that there are no (or fewer) laws in a messy world and, (ii), one can hold the view I have advocated above: that there are laws with exceptions in a messy world. However, if we underline the descriptive aspect of Humean laws we should expect the Humeans to opt for the acceptance of laws with exceptions.

Yet, one philosopher's conclusion is another philosopher's reductio. A proponent of necessary connections could claim that if Humeanism about laws makes the acceptance of laws with exceptions that easy then it can only show, once again, that the whole doctrine cannot be right. I turn to Armstrong's necessitarian view in the next chapter. Now, I will discuss some arguments against Lewis laws with exceptions from inside Lewis's theory.

2.2.4 AGAINST LEWIS LAWS WITH EXCEPTIONS

(1) Contradictory Quotes and a non-favourable Reading of Index Laws. There is some tidying up to do. How are we, for example, to explain the quotes I presented at the beginning of this chapter which counted against the possibility of laws with exceptions? Recall:

> Admittedly, we do speak of defeasible laws, laws with exceptions, and so forth. But these, I take it, are rough-and-ready approximations to the real laws. There [sic!] real laws have no exceptions, and never had any chance of having any. (Lewis 1980: 125)
>
> Few would deny that laws of nature, whatever else they might be, are at least exceptionless regularities. (Lewis 1986: xi)

Are these quotes contradicting the conclusion I have come to? Are they contradicting Lewis's own remark that "a version of the violated law, complicated and weakened by a clause to permit the one exception, may still be simple and strong enough to survive as a law." (Lewis 1973: 75)? I can extract three claims from these statements which stand, *prima facie*, in contradiction to "the violated law may still survive as a law":

(i) Laws with exceptions are rough-and-ready approximations to the real laws.
(ii) Real laws have no exceptions.
(iii) Laws are exceptionless regularities.

I think we can give an interpretation to all three quotes which allows them to cohere with my overall conclusion about Lewis laws.

It is relatively easy to deal with (i). We can interpret this statement as methodological advice: of those *alleged* laws we know today those with exceptions should be taken to be a 'rough-and-ready approximation to the real laws'. Sooner or later, so the hope is, we discover the true strict law. Why should we stick to this hope? Partially because we believe in the uniformity of nature and partially because a candidate system with strict laws seems to have more chances of winning the best system contest than a system with laws with exceptions. In other words, the first occurrence of the word 'laws' in (1) refers to 'laws as we know them' or 'law hypotheses'.

When it comes to (ii) and (iii) it takes more imagination to find an interpretation that coheres with the possibility of laws with exceptions but it is possible to find one. Suppose $\forall u\ (Fu \wedge \neg @(x, y, z, t)u \supset Gu)$ is the "version of the violated law, complicated and weakened by a clause to permit the one exception". We can, in some sense, truly say about this *complicated and weakened* law that *it* has no exception (in coherence with (ii)), for exceptionlessly all objects *u* that fulfil the antecedent of that law fulfil its consequent. In the same vein, we can say about this law that *it is an exceptionless regularity* (in coherence with (iii)). Hence, in this sense, the "violated law" neither opposes (ii): "Real laws have no exceptions", nor (iii): "Laws are exceptionless regularities".

There is, of course, also an important reading of $\forall u\ (Fu \wedge \neg @(x, y, z, t)u \supset Gu)$ in which it really does contradict Lewis's statements (ii) and (iii) and this is very desirable if we want to be able to speak at all of a law with exceptions. The description of the whole affair which does contradict Lewis is the one that says that the almost universal regularity *Fs are Gs* has a single exception at space-time point (x, y, z, t).

Have I stretched the Lewis interpretation a bit? I don't think so. Actually, the two different perspectives on ∀u (Fu ∧ ¬@(x, y, z, t)u ⊃ Gu)—the one treating it as the perfect universal statement it syntactically certainly is; the other focussing on the particular world history which it encodes—appear in Lewis's own writings. When it comes to measuring the similarity of worlds in respect to their laws, Lewis says that we could look at "the linguistic codification of laws" (Lewis 1979: 54)—this corresponds to my syntactic reading. However, he also insists "that there is another way of comparing similarity with respect to laws, equally deserving of that name […]. That is the way that neglects linguistic codifications, and looks instead at the classes of lawful and of outlawed events" (Lewis 1979: 55)—the latter view is the one which makes an exception at (x, y, z, t) visible.

Earlier, when I was talking generally about index laws and the epistemic trap (chapter 2.1.3) I warned that this trap can resurface in a different disguise. That is what has just happened: a language centred approach might judge that the index law is strict after all. However, I hope I have made strong the metaphysics focussed perspective which makes the exception visible.

(2) The Intrinsicness of Perfectly Natural Properties. A further difficulty looms. We might want to contend that a real lawlike regularity has to be a correlation between kosher, non-gruesome, i.e., perfectly natural properties and, whatever the definition of those 'ok-properties' is, *not being at (x, y, z, t)* does not seem to count as such.

The opinions we get from Lewis on that matter are potentially contradictory: on the one hand, what a perfectly natural property is stands and falls with what a law of nature is: "the discovery of natural properties is inseparable from the discovery of laws." (Lewis 1983: 38); "Laws and natural properties get discovered together" (Lewis 1983: 43). As a consequence, *not being at (x, y, z, t)* would, against possible prejudices, come out as a perfectly natural property if index-laws in fact figure in a best system.

On the other hand, Lewis "put forward the hypothesis that all perfectly natural properties are intrinsic" (Lewis & Langton 1998: 130). Yet, *not being at (x, y, z, t)* neither sounds very *intrinsic intuitively* nor does it fit Lewis and Langton's *definition of intrinsic*:

> A property is *intrinsic* iff it never can differ between duplicates; iff whenever two things (actual or possible) are duplicates, either both of them have the property or both of them lack it. (Lewis & Langton 1998: 121)

Now, one of two perfect intrinsic duplicates could easily be at (x, y, z, t) and the other somewhere else. Therefore, *not being at (x, y, z, t)* is not an intrinsic property. Consequently, it is not a perfectly natural property either.[11]

The easiest way out of the alleged contradiction is, of course, to read the 'inseparable' in Lewis's claim that "the discovery of natural properties is *inseparable* from the discovery of laws" (Lewis 1983: 38) in a weaker way than I have tacitly suggested. '*Inseparable*' should not stand for *if and only if* as in: 'a property is natural *if and only if* reference to it appears in law statements'. Rather, we should interpret appearance in laws only as a *necessary* but not a *sufficient* condition for naturalness. That gives those (few) properties mentioned in laws which are not natural (like *not being at (x, y, z, t)*) the freedom not to be intrinsic and the contradiction is resolved.[12]

Now, whether or not *not being at (x, y, z, t)* can count as natural there still remains the worry that it should not appear in laws in the first place simply because reference to individuals should not occur in laws. This is a matter of intuition. Luckily Lewis shares mine as he is happy to tolerate space-time points in laws:

> The ideal system need not consist entirely of regularities; particular fact may gain entry if they contribute enough to collective simplicity and strength. (For instance, certain particular facts about the Big Bang

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[11] The same holds for the positive *being at (x, y, z, t)*.

[12] An interesting follow up question would be whether—quite apart from index laws, indices, and the topic of exceptions—there are other non-natural properties in fundamental laws and, if so, what the feature is that separates them from the natural ones. Are all and only the extrinsic ones that appear in laws non-natural?

> might be strong candidates.) *But only the regularities of the system are to count as laws.* (Lewis 1983: 41; my emphasis)

And even more to the point:

> It is open that the best system might include truths about particular places or things, in which case there might be laws about these particulars. As an empirical matter, I do not suppose there are laws that essentially mention Smith's garden, the centre of the earth or of the universe, or even the Big Bang. But such laws ought not to be excluded *a priori*. (Lewis 1980: 123)

(3) What is strictness worth? The best system, so Lewis hopes, will be very far ahead of any other (good) system (cf. Lewis 1994: 233). Now, a question about the heuristics of how to arrive at the best system can bring out a potential difficulty: are we first to launch the competition for systems which solely contain strict laws and, only secondly, if this competition does not yield a winner, also allow systems which tolerate exceptions to compete? Or is the contest open to strict and exception ridden laws from the outset?

I have presented this dilemma as if it was about temporal order and scientific methodology but of course Lewis's theory is not meant to be a recipe for researchers to assemble the laws.[13] Naturally, the real difficulty is about the atemporal hierarchical standing of the different systems: is a system with only strict laws superior by default (just in virtue of its being a system of *strict* laws) to systems with non-strict laws or does system performance rely only and entirely on the strength, simplicity, fit, and balance of the law candidates in it?

Intuitively, we should not reward any brownie points for the strictness of a system.[14] If nothing else, this move would at least disturb the aesthetics of Lewis' theory by introducing an element which does not belong to the same category as strength, simplicity and fit. In fact, it is strength, simplicity, and fit which should be able to sort out automatically

[13] In some sense it is: of course scientists watch out for simplicity and strength. However, they do not run competitions between competing overall systems. It is in the latter sense that Lewis's theory is not meant to be a code of practice for scientists.

[14] I call a system strict if it includes only strict laws; non-strict if it has at least one law with an exception.

whether strict or non-strict systems win the race.

However, there is the following difficulty. Suppose the system which comes out robustly best contains laws with exceptions. Yet, suppose furthermore that there is also a system with only strict laws that is far ahead of its peer group (i.e., far ahead of other systems of only strict laws) while being somewhere in the middle compared to all the systems (i.e., systems including laws with exceptions). This strict system might be weaker than the non-strict winner just because it leaves out the exception ridden laws. What is our intuition in such a case?

One reaction could be to question the possibility of this scenario. It depends very much on how strength, simplicity, fit and their balance are actually measured, but it could be the case that whenever a non-strict system is the robust winner then there simply cannot be a clear best amongst the strict systems. The reasoning behind this claim could be this: for a non-strict system to be far ahead the world must be messy to a certain extend. In messy worlds, however, strict systems can never quite fit the phenomena so that none of them will be much better than the other strict ones.[15] Put in a catchy slogan: mess might make strictness mediocre.

Yet, how are we to decide whether this reasoning is correct? So long as strength, simplicity, and fit remain the vague notions they currently are I do not see a way to settle the issue. So suppose again that the following scenario is indeed possible. There is an overall non-strict winner far ahead of all systems and a strict winner far ahead of all strict systems. That being the case some might want to opt for the subsequent alternative after all: a strict system should win over a non-strict system if it fulfils Lewis's competition criteria within its peer group no matter how far ahead the non strict-system is. Only in the very exceptional circumstances where no strict system is ahead of any other strict system can we consider non-strict systems as winners.

I fear I cannot resolve this issue here and it has to remain an open question how we best decide, but note that even if there can only be non-strict laws in the just mentioned very exceptional circumstances, they

[15] It is enough to suppose that there is always at least one draw between two systems.

remain, after all, a possibility for Lewis.

Another question is whether Lewis's talk of a “robustly best system” implies that a certain minimal standard has to be met. If we take non-strict laws on board this question is even more pressing. For it seems that in a very messy world with, intuitively, no laws at all, some system of non-strict laws could still come out as robustly better than any other system even though it would be extremely weak by the high standards we expect from, for example, the system of our world. Again, I have to admit that I do not know how to answer this difficulty.

Once we accept non-strict laws there are further difficulties of a more technical nature with Lewis’s idea. We surely would like to know, for example, when two worlds agree on their laws. That task was easy when laws were strict, but is not so when the laws can have exceptions. Suppose that world w lasts from time t_1 to time t_2, world w* a little longer from t_1 to t_3 ($t_1<t_2<t_3$). Let w and w* agree in all their laws but L. For L it is controversial whether they agree for the following reason: in w let L be the law ∀u (Fu ⊃ Gu). In w*, however, ∀u (Fu ∧ ¬@(x, y, z, t*)u ⊃ Gu) holds instead with $t_2<t^*<t_3$. Now, do w and w* agree in all their laws? Or consider this case: both w and w* last from t_1 to t_2. ∀u (Fu ∧ ¬@(x, y, z, t)u ⊃ Gu) is a law in w, however, ∀u (Fu ∧ ¬@(x, y, z, t*)u ⊃ Gu) with $t \neq t^*$ is a law in w. Do they agree in that law?

I have labelled these questions as technical difficulties. I hope they do not hide a more substantial aspect because I do not examine them further. Instead, I will now turn to the two traps alleged laws with exceptions might fall into.

2.2.5
DO WE AVOID THE EPISTEMIC AND THE PROBABILISTIC TRAP?

The Epistemic Trap. When I was imagining or spotting possible candidates for laws with exceptions in the previous chapter I warned of two traps into which one could fall while trying to imagine such laws. The first, the epistemic trap is activated if the alleged law with exceptions turns out to be a mere law hypothesis which, after reformulation, reveals a strict law. I have also mentioned a variant of the epistemic trap in the first part of chapter 2.2.4 where an opponent of laws with exceptions could—focussing on language—insist that index law statements are strict universal statements after all. The original epistemic trap is, fortunately, automatically disarmed for Lewis's theory since I have exactly modelled Lewis's laws with exceptions after index-laws so that my general arguments from chapter 2.1.3 can be reapplied. I hope to have disarmed the language centred variant of the trap in 2.2.4 where I made strong the position which "neglects linguistic codifications, and looks instead at the classes of lawful and of outlawed events" (Lewis 1979: 55)

The Probabilistic Trap. A trickier task is to avoid the second difficulty: probabilistic trap. In order to see the difficulty we have to remember how probabilistic laws figure in Lewis's best systems. Laws summarise in the best way possible the patterns of the mosaic of fundamental properties on which everything else supervenes. Some regular patterns in this mosaic can be described by strict universal generalisations, some cannot. Some of those that cannot can be captured by chance laws. However, and this is the difficulty in this chapter, those that cannot might also be captured by laws with exceptions and our problem is how to choose between the two possibilities.

The conceptual difference between both kinds of law is not negligible: the probabilistic law claims that each time the antecedent is fulfilled there is a certain chance for the consequent to be instantiated while the law with exceptions says that, in almost all cases, it is assured that where the antecedent is true so is the consequent. Consider the following example. Suppose we come across the pattern 'xxxxxxoxxx'. Is it a law that all points are occupied by *x*s except for the seventh or is it a law that all points have a 9/10 chance of being occupied by *x*s? According to the law with exceptions it is (physically) impossible for the first point not to be an x whereas this *is* (physically) possible for the probabilistic law.

Now, the pattern of properties is itself indifferent to which kind of law is the right one to pick since objective chances do not themselves appear in the mosaic. Rather, the chances there are in the world are a consequence of which system of (alleged) laws wins the competition. This, of course aggravates the problem. Recall Lewis: some laws

> will say […] what the chances will be when situations of a certain kind arise. […] And further, some will fit the actual outcomes and the history better than others. That is, the chance of that course of history will be higher according to some systems than according to others. […] The virtues of simplicity, strength, and fit trade off. The best system is the system that gets best balance of all three. […] some of the laws are probabilistic. So now we can analyse chance: the chances are what the probabilistic laws of the best system say they are. (Lewis 1994: 234)

There are, however, some clues as to how to decide whether a law is a probabilistic or an index law. The most obvious, but also most unspecific one, is to say that the probabilistic law rather than the law with exceptions has to be chosen if it contributes better to the system's simplicity, strength, fit, and the balance of these.[16] We get more specific ideas when we deal with each criterion in turn: although simplicity is left rather vague by Lewis I think it is safe to say that a probabilistic law is simpler than an index-law, especially if the latter lists quite a few exceptions. When it comes to strength index-laws win. They, unlike the probabilistic laws, tell us exactly where the consequent of the law is not instantiated.[17] Here, I interpret strength as the virtue of picking out a relevant regularity which covers a considerable chunk of world history (as opposed to saying something about coins in my pocket, for example). When it comes to fit (which can be seen as a special kind of strength) again the index-law is ahead because it is supposed to have 100% fit whereas the probabilistic law's probability might divert from the actual frequency.

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[16] The competition is, of course, a competition between *systems* of alleged laws so that the comparison between laws I utilise here has to be understood as a derivative of system comparison.

[17] This is true unless we record index-laws much more vaguely: 'Almost all Fs are Gs'. In this case the probabilistic laws might win the strength contest because they give us the probability with which to expect an F to be G.

There are also holistic considerations to be made which cannot be decided by looking at the laws in isolation. I have mentioned them already in a previous chapter: laws form a net so that, for some of them, if they have an exception at a certain space-time point others are likely to have an exception as well. Now, if these laws are taken to be probabilistic with high positive probability it would be extremely unlikely that they have a gap in common. Intuitively, this scenario counts against probabilistic laws and for laws with exceptions. Also of a holistic nature are considerations concerning families of laws: laws about half-life periods of radioactive elements are either all based on probabilistic processes or none of them is.

In the last two sections I have collected some vague clues as to how to decide between probabilistic laws and laws with exceptions. I fear that in the end, only a precise definition of simplicity, strength, and fit could decide for one rather than the other kind of law. This rather unsatisfactory conclusion seems of little help in countering the danger of the probabilistic trap. Yet, the situation is not as bad as it appears. After all, our problem is not that it is, in Lewis's framework, impossible to disentangle the two concepts—probabilistic law vs. law with exception. Rather, the difficulty is merely to decide which of the two kinds of law describes certain phenomena correctly. Once we see that the decision making rather than the characterising is the problem it is easier to accept that there is, as yet, no clear and decisive procedure available to determine which regularity amounts to which law.

Probabilistic laws with Exceptions. A further, yet different, question is whether Lewis's system allows for probabilistic laws with exceptions. A believer in primitive objective chances can easily conceive of such laws: at indices the objective chance changes (see chapter 2.1.6). This can be independent of actual frequencies. For Lewis, however, objective chances supervene on the actual pattern of property instantiations. Actual frequency is a very important factor (although not the only one) that helps fix objective chance (the other factor being, of course, system performance):

> In the simplest case, the best-system analysis reduces to frequentism. [...] For we get the best fit by equating the chances to the frequency; and the larger the class is, the more decisively is this so. (Lewis 1994: 234-235)

Now, can we conceive of a case in which a Lewis system could admit a probabilistic law with exceptions? I think so. Suppose that the frequency of Gs amongst Fs is generally f(Gu|Fu)=r. Also suppose that this frequency differs radically at space-time region (x, y, z, t) (a spatially relatively small but temporally extended place, say): $f(Gu|Fu \wedge @(x, y, z, t)u) = r^*$ ($r^* \neq r$). Of course, this is, so far, nothing much in favour of a probabilistic law with exceptions. When tossing a fair coin there is a 50-50 chance it will come up heads and yet when tossing it for a million times there could be long stretches when only heads are shown. This would not yet lead us to postulate a law with exceptions because extended local deviations from overall frequencies are compatible and even to be expected with chance-laws. So, suppose furthermore, that (x, y, z, t) is an infamous index: each and every non-probabilistic law-candidate fails there but nowhere else. Isn't it imaginable, then, that a system comes out best which contains law candidates that have an index at (x, y, z, t), *including the probabilistic law under consideration* (and, most likely, other probabilistic laws)? It all depends again on system performance and the way strength, simplicity, fit, and their balance is measured. Although there is no decisive answer the possibility for the existence of probabilistic laws with exceptions seems to be there.

2.2.6 SUMMARY

This concludes my inquiry into whether Lewis's theory of laws of nature can allow for laws with exceptions. The answer is positive: the present law hypotheses of physics including their breakdowns at black holes could be accepted by Lewis's theory if they turned out to be true. Index laws are also acceptable. Both the epistemic and the probabilistic trap are avoided in Lewis's system.

2.2.7 EXCURSUS: A BRIEF COMPARISON TO BRADDON-MITCHELL

In his article ‘Lossy Laws’ Braddon-Mitchell also claims that a derivative of Lewis's theory of laws of nature can allow for exceptions (Braddon-Mitchell 2001). Braddon-Mitchell's derivative differs a little from mine in that it explicitly allows law statements to lie. That is, he opts for recording the law as $\forall u\ (Fu \supset Gu)$ even if there is an exception at (x, y, z, t). This conflicts with my suggestion of writing $\forall u\ (Fu \wedge \neg @(x, y, z, t)u \supset Gu)$. Yet, his argumentation for the overall possibility of accommodating exceptions resembles mine. Here is a very short outline in his own words:

> Rather than start with systems that tell only the truth, we start with systems that tell *mostly* the truth. Not any system that tells a few lies will be admitted of course; the justification for the lies has to be that there are generalisations included which hold for the most part, but because they fail sometimes errors are introduced—the law says all Fs are Gs, but the occasional F isn't and for no apparent reason. We of course reject any such system that fares no better in terms of simplicity and power than ones which tell only the truth, but leave open the possibility that the one which best trades off these desiderata may be one which includes powerful unifying regularities to which, as a matter of fact, there are exceptions, and which thus violates the accuracy desideratum of telling nothing but the truth. (Braddon-Mitchell 2001: 266)
>
> Note that a false law is just one which makes a false generalisation. It's still a law just so long as the generalisation is part of the system which best trades off power, simplicity and accuracy. It's not the old distinction between mere lawlike generalizations, and the laws. (Braddon-Mitchell 2001: 267)[18]

I will briefly point out why I have a slight preference for the account of index laws I have offered but I will also give an argument in favour of Braddon-Mitchell’s variant. If the sole issue was loyalty to Lewis (which it surely is not) then my view would be more obedient simply because Lewis’s quote that “a version of the violated law, *complicated and*

[18] I think it is better to speak of a ‘broken law’ rather than “a false law”.

weakened by a clause to permit the one exception, may still be simple and strong enough to survive as a law" (Lewis 1973: 75; my emphasis) is more in line with my Lewis derivative than with Braddon-Mitchell's: my law statements are, in fact, complicated and weakened by such a clause. More convincing, Braddon-Mitchell's lying laws stand in opposition to Lewis's demand that the best system "must be entirely true" (Lewis 1983: 41)[19] and I believe that lying laws somewhat contradict everyone's intuition: whatever else law statements might be they must at least be true.[20] 'It is a law that…' should simply imply 'it is the case that…'.

However, there's also a good point to be made in favour of Braddon-Mitchell's way to record the law. Because it is *lying* his 'All Fs are Gs' is certainly a law which fails at the index. No sophistic twist can be made like in the case of my ∀u (Fu ∧ ¬@(x, y, z, t)u ⊃ Gu) which is syntactically strict, and gappy only when seen from the perspective of "the classes of lawful and of outlawed events" (Lewis 1979: 55) (cf. my 2.1.3 and the first part of my 2.2.4).

This already concludes my comparison of the two accounts. My disagreement with Braddon-Mitchell might, in the end, come down to no more than the purely verbal issue of how to note down the law statements of the laws with exceptions we both accept. The way we arrive at those laws is very much alike.

I end this paragraph by pointing out parallels to some other fields of inquiry. In his article, Braddon-Mitchell associates the mechanism with which the system of laws is compiled to data compressing algorithms we are all familiar with: take jpeg pictures or mp3 music files. I would like to add that, in fact, we encounter best system analyses, or similar methods, more often than we might think—even in philosophy. Think of, for example, the Quine/Davidsonian enterprise of radical translation/interpretation. It, too, tries to describe or interpret the raw material—i.e., all

[19] Also: "what we value in a deductive system is a properly balanced combination of simplicity and strength as much of both *as truth* and our way of balancing will permit." (Lewis 1973: 73; my italics)

[20] Ironically, Nancy Cartwright's dictum of the lying laws of physics would be correct for Braddon-Mitchell's laws—however, not at all in the way she has envisaged.

utterances of a speech community—in an as brief and concise manner as possible. Best overall fit is attempted through, for example, the application of the principles of charity and humanity. Slips of the tongue, malapropisms, or idiosyncrasies of individual speakers can, however, be tolerated by the system. Note that the latter occurrences are nothing but exceptions to the 'meaning laws' and Davidson treats T-sentences indeed as laws: "Since I was treating theories of truth as empirical theories, the axioms and theorems had to be viewed as laws." (Davidson 1984: xiv)

2.3
FUNDAMENTAL LAWS: DAVID ARMSTRONG

2.3.1
INTRODUCTION

What Armstrong calls ‘*oaken*’ or ‘*defeasible laws*’ in his theory of lawhood are, *prima facie*, fundamental laws that could, unlike their ‘*iron*’ siblings, fail to hold. This seems to be a promising start for the aim of this chapter: to establish whether there is a possibility for the existence of fundamental laws with exceptions in Armstrong's theory. Appearances are, however, deceiving: I will show that some of Armstrong’s defeasible laws fall victim to the epistemic trap and, moreover, that they lead us onto metaphysically dubious ground.

Next to defeasible laws, Armstrong suggests a second way in which laws can fail to hold. This and a third way in which I try to implement a derivative of my index-laws in Armstrong’s theory are more promising. In a final, fourth attempt I inquire how Armstrong’s theory can accommodate laws with singularities.

Parallel to my chapter on Lewis's laws I shall first outline Armstrong's theory in as much detail as is necessary to tackle the main question of this chapter. Only afterwards will I turn to the four possible ways of implementing laws with exceptions. Subsequently, short passages on how the epistemic and probabilistic trap are avoided (or not) follow.

2.3.2 THE ARMSTRONG INTERPRETATION OF LAWHOOD[1]

As pointed out a few times, most philosophers agree that in order to distinguish laws from accidental regularities a law must be a regularity *plus some X*. For Lewis this *X* is membership in that deductive system which, roughly, describes the world's history in the simplest, strongest, and best fitting way. Metaphorically speaking, Lewis throws out a net in order to capture the laws so that whether a regularity is a law depends holistically on features of the whole web of laws. Armstrong, on the other hand, seeks to anchor those regularities which deserve law status in deeper grounds: *Fs are Gs* is a law just in case the *universal* F stands in the *nomological necessitation* relation to the *universal* G, in short N(F, G) (also, in later writings, C(F, G)).[2] In fact, Armstrong calls the (second order) state of affairs, C(F, G), the law. That the regularity $\forall x\ (Fx \supset Gx)$ holds is, according to Armstrong, just a consequence of C(F, G).

[1] Although Armstrong's theory is expressed in more detail in his earlier book *What is a Law of Nature* (Armstrong 1983) I will mainly rely on his later *A World of States of Affairs* (Armstrong 1997) where he has modified his initial theory slightly. Yet, I will not include the very latest surprising twist in his view on laws which he spelled out in 'How Do Particulars Stand to Universals?' (Armstrong 2004). There, Armstrong suggests that the "fundamental tie" between particulars and universals is to "be construed as an intersection, a partial identity, of the particular and universal involved" (Armstrong 2004: 146). As a result, particulars instantiate universals necessarily rather than contingently. Contrary to what he propagated in earlier works, Armstrong adds in a footnote: "If one thinks of nomic connections as a higher-order relation holding between first-order universals, and one extends the partial identity idea to this predication, then laws of nature become (strictly) necessary—an unexpected result, but not unwelcome to me." (Armstrong 2004: 146, fn.8) Previously Armstrong had fervently argued against the strict necessity of laws (cf., for example, Armstrong 1983: 158-171).

[2] Armstrong is not the only philosopher pursuing this idea. I take it, however, that the positions of, for example, Michael Tooley (Tooley 1977) and Fred Dretske (Dretske 1977) are, although different in detail, similar enough to Armstrong's. Seen from the viewpoint of my project, Armstrong can serve as proxy for all of them.

What are *universals* and what is the *nomological necessitation relation*? First universals: Armstrong takes universals to be states-of-affairs types where states of affairs are the fundamental constituents of his ontology:

> We are asking what in the world will ensure, make true, underlie, serve as the ontological ground for, the truth that *a* is F. The obvious candidate seems to be the state of affairs of *a's being F*. (Armstrong 1997: 116)
>
> If a particular *a* has the property-universal F, then the state of affairs is *a's being F*. For convenience we may continue often to refer to the universal by the mere letter 'F'. But it is best thought of as *_'s being F*. Similarly, we have *_'s having R to* _. The universal is [...] everything that is left in the state of affairs after the particular particulars involved in the state of affairs have been abstracted away in thought. So it is the state-of-affairs type, the constituent that is common to all states of affairs which contain that universal. (Armstrong 1997: 28-9)

There are two further important features of Armstrong's universals: they are strictly identical in their different instances (cf. Armstrong 1997: 28) and they have existence only in so far as they are instantiated (cf. Armstrong 1997: 38ff). It is not necessary to go into further detail about Armstrong's ontology of universals.

Hence, I come to nomological necessitation: nomological necessitation is the relation-type of which singular causation is the token instantiation:

> Nomic connection can be understood as the sort of connection actually encountered in certain cases of singular causation. (Armstrong 1997: 232).
>
> Singular causation is no more than the instantiation of this type of relation in particular cases. When we experience singular causation, *what* we are experiencing is nomicity, law-instantiation. (Armstrong 1997: 227)[3]

In his earlier *What is a Law of Nature* Armstrong had not yet pointed out this very tight relation between causation and nomological necessity. At that time, Armstrong used ***N(F, G)***—for *F* ***n****omologically* ***n****ecessitates*

[3] It would be better to speak of, for example, 'causality in the situation', as Armstrong sometimes does, instead of 'singular causation'. The latter has the connotation of being not regular and not nomological (because being 'singular'). I will, like Armstrong, nonetheless use 'singular causation' purely meaning 'causality in the situation'.

G—as a notation for a law-relation rather than ***C(F, G)*** or "($\_{1}$ being F) ***causes*** ($\_{2}$ being G)" as he prefers now to write (he also sometimes writes "F→G") (cf. Armstrong 1997: 230).

Armstrong attributes two interesting features to causation: (i) it is observable: "causation is given in experience" and "the dyadic predicate 'causes' is as much an observational predicate as any other predicate in our language, especially in such cases as our awareness of pressure on our own body." (Armstrong 1997: 228); (ii) singular causation is—not conceptually, but rather as an empirical, *a posteriori*, matter of fact—no more than, i.e., identical to, the token instantiation of the nomic relation. This identity is metaphysically necessary, i.e., there is no genuine singular causation without there being law instantiation.[4]

> *The fundamental causal relation is a nomic one, holding between state-of-affairs types, between universals.* Singular causation is no more than the instantiation of this type of relation in particular cases. When we experience singular causation, *what* we are experiencing is nomicity, law-instantiation. Or so my hypothesis goes. Of course, we do not *experience* it as nomicity, in the way we do sometimes experience singular causation as causation. (Armstrong 1997: 227)
>
> Why should it not be the case that the identification of a singular causal sequence with the instantiation of a law (singular causal sequence=instantiation of some particular law) is not conceptual, but rather an empirical, *a posteriori*, matter? […] The empirical evidence for the suggested identity is just that the *patterns* of singular causation exhibit regularity, regularity that is evidence for a law. (Armstrong 1997: 218-9)
>
> If one holds, with Kripke, that these identifications are necessary truths then these are empirically justified necessities. (Armstrong 1997: 218)[5]

[4] Armstrong sides with Anscombe (Anscombe 1971) in so far as he sees no conceptual, *a priori* entailment between singular causation and law instantiation but he sides with Davidson (Davidson 1967) in so far as he believes that all instances of singular causation are law instantiations. Armstrong adds that this is not just a contingent matter of fact but is metaphysically necessary.

[5] In *A World of States of Affairs* (Armstrong 1997) this view is presented cautiously as a conditional: "*if* one holds, with Kripke…". It is, however, quite clear from other writings that Armstrong does endorse Kripke's necessity: "The identification of

It is crucial to mention one further feature of Armstrong's relations of nomological necessity: it is supposed to hold contingently, i.e., in case of C(F, G), the second order state of affairs that the universals F and G stand in the two place second order relation C holds contingently. It could be different, i.e., there are metaphysically possible worlds in which different laws hold (cf. Armstrong's chapter *Are the laws of nature necessary or contingent?* in (Armstrong 1983: 158-171)).

Here is a summary of Armstrong's view on laws in his own words:

> A *law*, it is our hypothesis, is something stronger than a universally quantified state of affairs, even a universally quantified state of affairs involving singular causation. It is a causal connection between state-of-affair types. It is a 'direct' connection between these state-of-affairs types, that is, between universals. (Armstrong 1997: 226-7)
>
> [A law] is a second-order state of affairs, a relation holding between the universals involved. This second-order state of affairs must itself be a universal, a structural universal involving a certain linking of universals, a linking of state-of-affairs types. (Armstrong 1997: 226-7)

Difficulties arising from Armstong's theory. There are, however, certain difficulties with Armstrong's view. After he had presented his theory for the first time in *What is a Law of Nature* (Armstrong 1983) van Fraassen challenged the theory with what he called the *identification problem* and the *inference problem* (cf. van Fraassen 1989: 96ff; and also Armstrong 1997: 228). The solution Armstrong offers in his later *A World of States of Affairs* (Armstrong 1997) for the inference problem is particularly interesting for the issue of laws with exceptions. Before I come to Armstrong's answer I briefly introduce van Fraassen's problems.

The *identification problem* asks which relation between universals nomic necessity is; the *inference problem* is the question: "what information does the statement that one property necessitates another give us about 'what happens and what things are like' (the regularities)?" (Armstrong 1997: 227-8), i.e., the inference problem asks how C(F, G) entails or secures $\forall x\ (Fx \supset Gx)$.

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singular causation with instantiation of strong laws is, we think, a 'Kripkean' necessity." (Armstrong & Heathcote 1991: 69)

From the perspective of his later book the identification problem seems to be pointless. Indeed, in his earlier publication, which van Fraassen criticises, Armstrong had not yet made the close link between causation and nomicity so that van Fraassen's riddle could have its bite. Now, however, the solution is obvious: “The Identification problem is solved via our direct awareness, in certain favourable cases, of causation in the *token* case.” (Armstrong 1997: 228) (This solution is, of course, only obvious for anyone who believes in the observability of causation and its identification with token nomicity. I will, for the sake of the argument, take both for granted.)

The inference problem is harder to answer. Armstrong offers us four lines as solution:

> When one particular state of affairs brings about another, then the *pattern* instantiated, one state-of-affairs type bringing about a further state-of-affairs type according to some pattern, is a 'direct' relation between the state-of-affairs types involved, *a relation that is the causality instantiated in the situation*. (Armstrong 1997: 228)

I hope to do justice to Armstrong when I interpret his words in the following way: F and G are universals and so is C. C, however, is a second order universal, holding between universals. What we suppose when we suppose that *Fs are Gs is a law* is that it is ‘a second-order state of affairs’ that C holds between F and G (cf. Armstrong 1997: 226-7). Now, if the universal, i.e., state-of-affairs type, F is instantiated so must be C(F, G). The instantiation of C(F, G), however, “is the causality instantiated in the situation”. Hence, the state-of-affairs type G must be tokened as well since it is caused by the F-token.[6] Accordingly, every instantiated F causes a G and so, as a consequence, $\forall x\ (Fx \supset Gx)$. Therefore, $\forall x\ (Fx \supset Gx)$ is ensured because of C(F, G) and “this would seem to solve the inference problem” (Armstrong 1997: 228).

[6] Something is puzzling, though: C is a second order universal and C(F, G) is a second order state of affairs. Now, to speak of C(F, G) as being instantiated (tokened) as causality between the F- and G-tokens is to treat C(F, G) not only as second order state of affairs but also as first order universal. Armstrong remains silent about these issues in *A World of States of Affairs* but in his earlier book we find a passage which endorses (or, at least, accepts) this double role (cf. Armstrong 1983: 96-99). I will accept this puzzling move uncritically.

Or does it? Surprisingly, Armstrong denies that the inference goes through as the argument stands. Yet, he is still convinced that van Fraassen's problem is solved. How is that possible? What van Fraassen doubted is that there can be an inference from C(F, G) to ∀x (Fx ⊃ Gx) *in principle*. This fundamental doubt is supposed to be dispelled by the above move. The addenda Armstrong sees a need for are just a marginal issue.[7] This is why I allow myself to take for granted that the inference problem as such is solved. Now, what are these mysterious addenda or provisos which have to be considered? The answer to this question brings us to the main issue of this chapter—laws with exceptions—for where provisos to laws are necessary there is, *prima facie*, an exception possible to what the law demands without the proviso.

2.3.3 ARE FUNDAMENTAL LAWS WITH EXCEPTIONS POSSIBLE?

Armstrong concludes his argument against van Fraassen's inference problem:

> Wherever the antecedent state-of-affairs type is instantiated [a being F, for example; MAS], then, assuming this law [C(F, G); MAS] is a deterministic one, it must *(subject to an already signalled qualification,* to be discussed almost immediately) produce the consequent state of affairs [a being G, for example; MAS]. (Armstrong 1997: 228; my italics)

Or, as he writes in *What is a Law of Nature* on this matter:

> I have up to this point written as if: (1) N(F, G) entails (2) (x) (Fx ⊃ Gx). I now modify that claim. For there to be an entailment, the scope

[7] Compare: from '2+2=4' you cannot, in principle, infer something about the fragility of glass. Neither can you infer anything from 'molecular structures of kind XYZ break easily when struck' but the latter is not a matter of principle: it takes only the additional information that glass has the relevant molecular structure to make the inference valid. It is in this vein that Van Fraassen's problem is solved although some loose ends are still to be tied.

> of (2) must be narrowed from *all Fs* to *all uninterfered with Fs*. (Armstrong 1983: 149)

The *qualification* Armstrong is talking about is a proviso clause which, allegedly, needs to be added to C(F, G) so that the regularity $\forall x\,(Fx \supset Gx)$ is entailed. Why is this so? Armstrong writes: "The entailment actually holds only for the case where it is given that *nothing further interferes*" (Armstrong 1997: 230).[8] He gives the following illustrative example:

> The gravitational laws give the gravitational forces holding between two bodies having certain masses and a certain distance from each other. It is not necessary that these forces cause the two bodies to move towards each other. There may be many other bodies also exerting gravitational force in the situation, not to mention other types of forces […] that may be operating. The two bodies are caused to move towards each other according to the law that governs just two massive bodies *provided nothing else interferes*. […] We can never rule out the possibility, mere possibility though it may be, that further forces […] could be added to the situation which would alter the behaviour of the particulars involved. Hence we cannot get our entailment without adding the clause that excludes further factors. (Armstrong 1997: 230-1)

There are many interesting and illuminating things to be said about this example and Armstrong's analysis of it. Before I begin the discussion, note, however, that Armstrong's example highlights a special case only, namely that of force laws. Hence, we can regard the next few sections as a short interlude on the particular case of force laws. Afterwards I will discuss Armstrong's case for all other kinds of law.

Before I turn to Armstrong's example about gravitation, let me briefly lay out the programme for the rest of this chapter. As I have just pointed out, I will, after having dealt with Armstrong's example about force laws, consider defeasible laws in general in 2.3.3.1, then, in 2.3.3.2, turn to an option where C(F, G) ceases to hold. I will discuss index laws in 2.3.3.3 and laws with singularities in 2.3.3.4.

Now, however, I turn to gravitation. First, note that Armstrong seems not to be consistent when it comes to the content of the law of gravitation:

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[8] Armstrong's concept of entailment or inference is, it should be underlined, slightly dubious. Apparently he must mean a kind of non-deductive reasoning.

is it that there is a force, F, if two bodies have certain masses, M_1 and M_2, and a certain distance, D, from each other *or* is it that bodies accelerate towards each other (with acceleration A) if they have certain masses and a certain distance from each other? That is, is the law something like $C(M_1 \wedge M_2 \wedge D, \mathbf{F_G})$ or rather $C(M_1 \wedge M_2 \wedge D, \mathbf{A_G})$?[9] The line "the gravitational laws *give the gravitational forces holding between two bodies* having certain masses and a certain distance from each other" counts for the former, the line "The two bodies *are caused to move towards each other* according to the law that governs just two massive bodies provided nothing else interferes" counts for the latter.

Maybe, the answer to my question is this: 'the gravitational laws give the gravitational forces holding between two bodies having certain masses and a certain distance from each other' *means that* or *is equivalent to* 'the two bodies are caused to move towards each other according to the law that governs just two massive bodies provided nothing else interferes'. Although I think that this answer is not entirely wrong I also believe that it veils an insight worth uncovering. The equivalence between the two statements is correct only because of two intermediate, hidden steps:

I claim that the proper interpretation of the gravitational law is the first one from above: $C(M_1 \wedge M_2 \wedge D, F_G)$ (and not $C(M_1 \wedge M_2 \wedge D, A_G)$), i.e., it talks, first of all, about nothing but forces. The same holds for the other force laws. Coulomb's law, for example, can be rephrased as $C(Q_1 \wedge Q_2 \wedge D, F_C)$, etc.[10]

Note that each of these laws entail the respective regularity about the presence of forces—for the law of gravitation, for example, $\forall x,y\ (M_1(x) \wedge M_2(y) \wedge D(x, y) \supset F_G(x, y))$—without the need for any proviso: as soon as there are two masses in a certain distance, there is a force between them. The additional presence of Coulomb forces, for example, does not

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[9] I am aware of the fact that my formalisations in the coming sections are quite sketchy. I hope they illustrate the issues I would like to discuss without covering difficulties that would need further exploration.

[10] Physics presently knows four kinds of forces: gravitational, electromagnetic, strong and weak forces. If we are lucky, a Great Unified Theory will tell us that all forces are reducible to one fundamental one.

alter or, what would be even worse, remove the gravitational force. A Coulomb force might cancel out, enforce, or reduce *the effect* of an existing gravitational force, but from $C(M_1 \wedge M_2 \wedge D, F_G)$ we can, in any case, infer, without any proviso, the regularity that whenever there are masses in a certain distance then there is a force between them.

I claim furthermore that we have to add to our considerations, first, a law governing the interaction of a multitude of different forces (which might all have a different origin: mass, charge, etc.), and, second, a law mediating between total forces and accelerations. Luckily, these laws are well known: in fact, the first law says that all individual forces operating on a certain body with mass M add up by the means of vector addition—$C(F_1 \wedge \ldots \wedge F_n; \Sigma F_i)$—the second tells us that the so calculated total or resulting force operating on an object with mass M causes it to accelerate with $A=F_T/M$, that is $C(F_T \wedge M, A)$. Note that both laws are again in no need of any proviso: no matter what, the total force results from the vector addition of all individual forces, the acceleration of an object is measured by the total force acting upon it.

Now, as a result we get Armstrong's interpretation of the whole affair as a special case: should the total force only consist of one gravitational force then the resulting acceleration is precisely the respective gravitational acceleration, i.e., 'the two bodies are caused to move towards each other according to the [gravitational] law *provided nothing else interferes*'. However, the two intermediate laws I have added explain and dissolve the proviso Armstrong had to insert when he moves from forces to accelerations. Phrased more confrontationally, Armstrong's proviso blurs what can be said more clearly in terms of the two additional strict laws.

Unfortunately, Armstrong's proviso obscures more than that because it might give the impression that the law of gravitation, Coulomb's law, etc. are fundamental laws with exceptions. My expansion into separate strict laws shows that this is not the case. If we were to make this wrong move—from Armstrong's proviso to the conclusion that the force laws are laws with exceptions—we would treat what I have called *pseudo exceptions* as *real exceptions*. Remember the distinction between the two I introduced in PART 1: some unforeseen forces might counteract a certain, predicted, force—this amounts to a pseudo exception—*or* the force itself might disappear—which would be a real exception to the respective law that, normally, necessitates the force. The latter case would occur if C(F, G) itself stopped holding in particular cases (the result of which would possibly be that ∀x (Fx ⊃ Gx) does not hold) but this was not the issue here.

I have shown for a particular kind of law—force laws—that the proviso Armstrong sees as essential in order to ensure an inference from C(F, G) to ∀x (Fx ⊃ Gx) is not, in fact, necessary. If we interpret the force laws as claiming nothing but that there are forces (rather than accelerations) if masses, charges, etc. are around and if we introduce two additional laws—one about the vector addition of individual forces to one resulting force, and one about the acceleration resulting from that total force—we realise that all of these laws are strict. Not only has the proviso clause Armstrong wanted to add dissolved into the additional laws, but also it becomes clear that the sort of exception Armstrong had in mind was of the pseudo exception kind. This concludes the brief interlude on Armstrong's example.

We are left with two further issues: first, we have to turn away from the special case of force laws to a general form of laws and, second, we need then to ask whether, in Armstrong's theory, *real* exceptions to laws are possible. In order to tackle these issues we can follow two lines of thought in Armstrong. The first one (2.3.3.1)—where he introduces the concept of *defeasible* (or *oaken*) and *iron* laws[11]—covers the inference problem generally for any kind of law; the second one (2.3.3.2) asks whether relations between universals, such as C(F, G), can hold temporarily and is right at the heart of the issue of real exceptions to laws.

[11] Armstrong has changed his vocabulary in recent years: what he called "oaken laws", i.e., laws which do have exceptions of some sort, are now called "defeasible laws", strict laws still bear the name "iron laws". Since no change in theory is involved I will use "oaken" and "defeasible" synonymously.

2.3.3.1 DEFEASIBLE LAWS

Remember the inference problem: how does C(F, G) entail ∀x(Fx ⊃ Gx), if it does at all? Armstrong's answer was that if C(F, G) holds then every instantiation of F must be followed by an instantiation of the C-relation between F and G, i.e., a causation of G unless something interferes with the causation of G so that G is not actually brought about. Armstrong warned: "The entailment actually holds only for the case where it is given that *nothing further interferes*." (Armstrong 1997: 230) I discussed this issue above for a particular kind of law, force laws. I turn now to the general case. Armstrong writes:

> We can, though, distinguish between two types of law. If F→G (with some probability) is a law, and if it is *empirically* possible (nomically possible) that there is a universal F&H, and if in these circumstances the probability of an outcome of type G is altered, then F→G by itself is a *defeasible* law. […] It seems to be always possible that for any antecedent of a law there exists such an H. But it may not be empirically possible. If it is not empirically possible, then the law may be called an *iron* law. (Armstrong 1997: 231)

We must interpret these lines carefully. Note, first, that the phrase "with some probability" applies to the connection F→G, not to "is a law", i.e., F→G might be a probabilistic law which says that G occurs with a certain probability if F is the case. I will, however, deal with probabilistic laws later. For now, it is sufficient to suppose that the probability equals 1, i.e., that we have a deterministic law as before.

Now, how exactly do we have to imagine what happens in cases where an *a* is both F and H and, as a result, the causation of G is prevented? I can offer four possibilities. All, unfortunately, lead to trouble. In fact, the whole issue of defeasible laws confronts us with unsatisfying metaphysical consequences:

(a) There could be a further, higher order law which says that in situations where a first order state of affairs, like Fa∧Ha, obtains the initial law, i.e., the second order states of affairs C(F, G), ceases to hold. This seems far fetched for it is inconceivable that the obtaining of a contingent spatio-temporal first order states of affairs should cause a non-spatial, non-temporal second order state of affairs to come to an end.[12] Worse, the lapse of C(F, G) would have to be a local matter: while the *a* is not caused to be G other objects which are F (and F alone) should still obey the law. Yet, how could a non-spatial, non-temporal relation between universals cease to hold at a particular place? The question alone has the air of a category mistake. Therefore, I do not consider interpretation (a) any further.

(b) Maybe Armstrong instead means the following: in situations where a first order state of affairs Fa∧Ha obtains C(F, G) will, although it still holds as a second order state of affairs, *not be instantiated* as singular causation (i.e., Fa is not causing Ga). Again, this seems far fetched. The puzzle this time is how the obtaining of a contingent spatio-temporal first order states of affairs, Fa∧Ha, can manage to prevent C(F, G)'s instantiation. And even if we grant that it is possible then we should think that the power of first order states of affairs like Fa∧Ha to prevent C(F, G) from instantiating is law governed itself. This, however, is again a rather adventurous kind of law. Possibility (b) is, hence, also questionable.

(c) My penultimate interpretation is the following. Next to C(F, G), there could be a law C(F∧H, ¬G). So that, if *a* is both F and H, it is caused to be G (by being F) and it is caused to be ¬G (by being F∧H). Surely, this alternative is also untenable. Not only does Armstrong not allow negative universals like ¬G so that laws like C(F∧H, ¬G) are not admissible in the first place, but even if he were to grant ¬G into his ontology of universals a contradiction would be unavoidable: *a* simply cannot *be caused* to be both G and ¬G for it cannot *be* both G and ¬G. *Being caused* is a success verb: if something is caused to be G it is, thereafter, G. Or, the other way round, if something is not G it surely has not been caused to be G: "I think that we should deny that these are cases of causation […] no relation exists

[12] And yet, we will see in a section after this one (2.3.3.2) that Armstrong seriously considers it to be possible for C(F, G) to hold at certain times but not at others. However, he says nothing about whether the obtaining of C(F, G) and also the ceasing of C(F, G) can be *caused* and, *a fortiori*, he does not reveal whether he thinks that either can be caused by first order state of affairs.

without its full complement of terms." (Armstrong 1997: 75)[13]

Considering (a)-(c), it seems not to be possible to conceptualise what exactly happens when defeasible laws are defeated. This, however, could count as a *reductio*: there are no defeasible laws on the basis of Armstrong's theory. Yet, I have one more interpretation up my sleeve. I should, however, add a waiver clause before I start: this interpretation, also, leads us to adventurous metaphysics.

(d) What if we treat the general case of C(F, G) just like the case of force laws? Several transformations are necessary. First, we have to replace G by a kind of force, let's say G_{F+} (the '+' will be explained soon). Then, second, we could acknowledge the existence of other laws also involving 'forces' regarding G (these laws mirror the other force laws next to the law of gravitation, like Coulomb's law, etc.). Some of those could, however, be forces *preventing* the bringing about of G. This explains my use of the '+' above: G enforcing forces should be noted down by 'G_{F+}', G preventing forces by 'G_{F-}'. Furthermore, we introduce a (meta-)law that mediates between all forces regarding G. This law says precisely which G-force wins the battle should more than one (and particularly G enforcing *and* G preventing forces) be instantiated. Last, we have to build into this law that the winner takes it all, i.e., that the strongest G-force decides whether G comes about or not (*mutatis mutandis* if G should be a magnitude which can come in many different strengths).

The result is a welcome one: none of the newly formulated laws needs a proviso. The inference from $C(F, G_{F+})$ to $\forall x\ (Fx \supset G_{F+}x)$ or from $C(F, G_{F-})$ to $\forall x\ (Fx \supset G_{F-}x)$ is guaranteed. So is the respective inference from the law mediating the G-forces to the according regularity. We get the same pleasant consequence as for the force laws: provisos disappear into the additional laws. Moreover, the picture of what happens when laws are defeated—better: when laws are interfering—is reasonably coherent.

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[13] When it comes to probabilistic laws Armstrong writes accordingly: "Causation that is law-governed, but where the law is probabilistic only, exists only when, as one may say, the state of affairs falling under the antecedent of the law 'fires', that is, the potential cause actually brings about its effect." (Armstrong 1997: 75)

Yet, the metaphysical price we have to pay is high if not unaffordable: what are the ominous G-forces?[14] Are they powers or capacities, the existence of which Armstrong firmly denies? What exactly is it to prevent the coming about of G?

Having unsuccessfully considered four possible interpretations, the metaphysics of defeasible laws seems in no good state. What is the consequence of this predicament for my enterprise of inquiring whether Armstrong can allow for laws with exceptions? If there is no metaphysically acceptable picture of what happens when a defeasible law is defeated then there simply are no defeasible laws. In that case my question has, at least on this grounds, to be answered negatively. If, on the other hand, the contrived interpretation which introduces G-forces is tenable after all, then, again, provisos are not necessary for the inference from law to regularity and there is then, too, no reason to think of laws with real exceptions.

If I have not misinterpreted Armstrong or overlooked a further reading, then his own suggestion for laws that are not strict—defeasible laws—are not good candidates for fundamental laws with exceptions.

2.3.3.2
C(F, G) CEASING TO HOLD

I am presently collecting possible ways to conceptualise laws with exceptions in Armstrong's theory of lawhood. I have doubted his own suggestion for defeasible laws. Before I start considering old acquaintances—index-laws and laws with singularities—I would like to

[14] It is especially difficult to imagine what these forces are when it comes to laws like the law of atomic decay, $N(t)=N_0e^{-\lambda t}$, Heisenberg's uncertainty relation $\Delta x\Delta p\geq h/2\pi$, or energy, impulse, and other conservation laws. Or do those laws simply belong to the iron laws Armstrong envisages? Remember: "It seems to be always possible that for any antecedent of a law there exists such an H. But it might not be empirically possible. If it is not empirically possible, then the law may be called an I law." (Armstrong 1997: 231) Yet, our difficulty is more of a conceptual kind than it is an empirical issue.

introduce another Armstrong-specific possibility for proviso laws.

Real exceptions would occur—so one should think— if the law itself, i.e., C(F, G), were to have an exception. That is, if the second order state of affairs (that the universals F and G stand in the two place second order relation C) ceases to hold. But is that possible? I have already raised my doubts. Let us hear Armstrong on this matter.

That C(F, G) prevails is, according to Armstrong, contingent: there are possible worlds, different from ours, in which C does not hold between F and G (but between F and H, say). How about the actual world, then?

> Why cannot a law of nature, if conceived of as the holding of a contingent relation between categorical universals, change? Why may it not be that F has the nomic relation G at one time, but later, since the connection is contingent, this relation lapses, perhaps succeeded by F's being related to H? (Armstrong 1997: 257)

Surprisingly, Armstrong's verdict is that "It seems that I have to allow that contingent relations between universals can change." (Armstrong 1997: 258)[15]

I find Armstrong's claim puzzling for isn't he in danger of losing the advantages a strong theory of laws has over regularity theories? Armstrong pejoratively refers to the world of the regularity theorist as being "loose and separate" (Armstrong 1997: 261). Neither inductive steps nor counterfactual reasoning seem to be justifiable for "why […] should there be any good reason to believe that [a] regularity will continue?" (Armstrong 1997: 261) Yet, why should Armstrong be in a better position

[15] I want to point out that Armstrong's opinion about this affair has changed radically twice. In 1983, he wrote in *What is a Law of Nature?*: "If F and G are related by a dyadic relation, a relation whose terms are confined to these two universals, then it *cannot* be that they have this relation at one time or place, yet lack it at another. […] As a result, there can be no question of their being related in a certain way at one place and time, yet not being related in that way elsewhere." (Armstrong 1983: 79) In the intermediate period above he seems to have abandoned that view. Recently, however, Armstrong has started to reconsider his view on the modal status of laws (cf. Armstrong 2004: 146) and, as a result, he seems now to have returned to his original opinion. I will here rely on the theory from Armstrong's intermediate period. (If C(F, G) were to hold metaphysically necessarily then, it has to be said, the whole following assessment would have to be rewritten in major parts.)

if he allows the nomic relations to wither?[16] The reason he gives are, I think, not entirely convincing. He writes:

> If F-ness produced G-ness, then F-ness has the power to produce G-ness. […] It may at some point lose this power. […] But it did have this power at a certain point. Is it not an attractive and simple hypothesis that it *will continue to have this power* at all times and places? […] nothing comparable is available to regularity theorists, because they have such a deflationary view of singular causation. (Armstrong 1997: 261; my italics)

But couldn't the regularity theorist simply reply that for him or her it is an attractive and simple hypothesis to state that Fs will *continue to be followed by G* at all times and places? For Armstrong, 'power' seems to be the magic word which has additional argumentative force so that his argument is only possible for the defender of nomological necessity but not for the regularity theorist. However, how can what Armstrong means by power have this additional force? For he assures us that he does not mean the power of dispositional essentialists who suppose that certain universals have certain powers essentially: "Power here, of course, does not have to be understood according to the Dispositionalist model" (Armstrong 1997: 261). Surely, in the case of the essentialist we gain additional counterfactual and inductive force. Yet, if power means just the 'oomph' of singular causation which, according to Armstrong is conceptually truly singular (it does not entail the nomological link and even less a regularity) then he is in exactly the same position as the regularity theorist. And isn't that what he eventually concludes himself when he says, contradicting somehow his line of argument above: "It is true, though, […] that F may come to lack that power […] That debt must be paid to inductive scepticism" (Armstrong 1997: 261).

In any case, the issue of whether Armstrong loses the advantages he claims his theory to have over a regularity theory is marginal to my central question and, so, I leave it behind. It is more interesting to highlight a few consequences of his reasoning.

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[16] The contingency of the relation alone would not have the consequence of looseness: the relation could, although being contingent, hold throughout the entire history of the universe (with temporal necessity, so to speak).

Due to C(F, G), instantiations of Fs do cause instantiations of G. At some other point in time, however, C(F, G) could cease to hold so that instantiations of F would not cause G instantiations anymore. Therefore, there could be (at certain points of time) Fs that are not Gs.

Of course, it is possible that the mere F-G-correlation continues nonetheless as a pure matter of fact. The sudden lapse of C(F, G) might not result in any change in first order state of affairs at all, that is, it could still accidentally be the case that all Fs are Gs:

> Suppose that laws of nature are higher-order states of affairs involving (contingent) relations between universals. Then a world exactly like our world, but with these higher-order states absent, is a possible world. It would be a specimen of what Frank Jackson has called a Hume world, a cosmic coincidence world whose regularity mimics (miraculously!) the regularity imposed by the higher-order relation of universals. (Armstrong 1997: 197)

So far so good. The second order state of affairs—that the second order relation C holds between the first order state of affair types F and G—can fail to hold at certain times: "Contingent relations between universals can change over time." (Armstrong 1997: 260) We do not learn, however, whether that also holds for space: can contingent relations between universals change in different regions of space? It also remains mysterious how such a change could come about. Would it be predictable? Could we even influence it? Is it caused by something or does it just so happen? We do not find any hints in Armstrong's works and I will not speculate about these issues.

However, we can ask, on the basis of what has been said by Armstrong, whether the permission of change in time amounts to a concept of laws of nature that allows for exceptions and thereby come back to my central question. Maybe we are lucky this time.

It seems, C(F, G) ceasing to hold in the year 2054, say, and then holding again until the end of the universe might well qualify as an exception ridden law. Yet, someone could raise the following doubts: the law, that is, the relation C(F, G), either holds or it does not, i.e., F-ness either nomologically necessitate G-ness or it does not. If, at a certain time, it does not hold then there is no law. There not being a law, however, does not equal a law having an exception. Hence, even though Armstrong allows for the contingent nomological link to break temporarily we do not get laws with exceptions.

The reader will be reminded of the variant of the epistemic trap regarding index laws. Concerning those laws, I have argued in section 2.1.3 and again in 2.2.4 that a change of perspective from metaphysics to linguistics could make index laws appear strict. Similarly, for Armstrong's laws the tension lies between two possible interpretation of C ceasing to hold. I leave it an open question for now how we should evaluate these two interpretations. A similar issue will come up again when I now discuss index laws.

2.3.3.3
INDICES (CANDIDATE 1)

An index-law is, remember, a law that has an exception at a certain, probably small, space time region (x, y, z, t). I used the following scheme to describe these laws: $\forall u\, (Fu \wedge \neg @(x, y, z, t)u \supset Gu)$. This scheme is not readily applicable to Armstrong because, in his theory, laws are not to be confused with universal generalisations. Rather, laws are relations between universals so that the respective index-law candidate should be noted down by: $C(F \wedge \neg @(x, y, z, t), G)$. Yet, does Armstrong allow the possible existence of laws of this kind?

In his *A World of State of Affairs* we find the answer to this question. There, Armstrong wonders whether we might be living in an area of the universe which has its very own, local laws. Could it not be, he asks, that

> our laws are no better than local laws, laws whose scope embraces no more than a limited spatiotemporal area? Laws may take some such form as: (1) F & $Spacetime_1 \rightarrow G$, (2) F & $Spacetime_2 \rightarrow H$. (Armstrong 1997: 257)

Armstrong was inspired by Tooley's example of Smith's garden when he acknowledged the possibility of such local laws (cf. chapter 2.1.3). Now, the step from 'F & $Spacetime_i \rightarrow G$' (that is, $C(F \wedge Spacetime_i, G)$) to

C(F∧¬@(x, y, z, t), G) is marginal.

Two doubts have to be overcome, though. First, and that holds for *Spacetime*$_1$ as much as for *¬@(x, y, z, t)*, individuals, as opposed to universals, enter the laws. Surprisingly, Armstrong sees no difficulty:

> Tooley argues that the case shows that we might be forced to accept laws that bestow nomic powers on particulars rather than universals. I agree. […] We can think of the case Tooley envisages as one where the antecedent conditions of the law plugs in a particular, though one having certain universal properties—fruits in *Smith's* garden—creating a state-of-affairs type that is not purely universal. It does seem that such a bastard state-of-affairs type might have a unique causal power. (We may call such a type a quasi-universal.) (Armstrong 1997: 256)

Second, and here lies a difference between *Spacetime*$_1$ and *¬@(x, y, z, t)*, *not being at space-time point (x, y, z, t)* is a negative *quasi*-universal and, therefore, not allowed in Armstrong's ontology. Fortunately, C(F∧¬@(x, y, z, t), G) can easily be reformulated utilising the positive complement of ¬@(x, y, z, t): let ©(x, y, z, t) designate *the whole universe minus (x, y, z, t)* and let @©(x, y, z, t) designate the quasi-universal *being at* ©(x, y, z, t). Then the law, C(F∧@©(x, y, z, t), G), expresses that the relation C holds between F, the universe minus (x, y, z, t), and G.[17]

I come to an evaluation of C(F∧@©(x, y, z, t), G). I have argued in the previous section (2.3.3.2)—when I was considering cases where C temporarily stops holding—that one could claim that the law, i.e., the relation C(F, G), either holds or it does not. If it does not, it does not, yet, not holding does not equal having an exception. The same negative assessment could be given for the case now under consideration: C holds between F-ness, @©(x, y, z, t)-ness and G-ness. That C does not hold between F-ness, @(x, y, z, t)-ness (being at the index itself), and G-ness does not mean that C has an exception for these two universals and the index quasi-universal; it just does not hold between them.

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[17] 'The universe minus (x, y, z, t)' shall, of course, refer only to the universe regarded as a space-time container. The stuff in it does not enter into the relation. Also, if there is more than one index the complement will be a Swiss cheese: an entity with many holes in it.

Earlier, in chapter 2.1.3, I have warned of this catch-22 everyone who wants to find laws with exceptions finds themselves in. All I can do yet again—as in my defence of index laws in the chapter on Lewis: 2.2.4—is to try to make strong the reading which allows us to speak of C(F∧@©(x, y, z, t), G) and of the ceasing of C from above (2.3.3.2) as laws with exceptions. When I defended ∀u (Fu ∧ ¬@(x, y, z, t)u ⊃ Gu)[18] as a respectable candidate for being a law with an exception I argued that, although we deal, grammatically, with a perfectly general universal statement, this statement clearly encodes a general pattern *with one little gap*. In this vein we can now argue that, seen from the universe as a whole, it is justifiable to treat C(F∧@©(x, y, z, t), G) as a law with exception because, as opposed to ordinary laws, it is not the entire world that is governed but only a part of the universe (the same holds, *mutatis mutandis*, for C ceasing to hold). Hence, I believe that it is not completely obscure to claim that 2.3.3.2 and 2.3.3.3 offer laws with exceptions within Armstrong's metaphysics.

There are other difficulties with laws from 2.3.3.2 and 2.3.3.3. When comparing the case from 2.3.3.2 (C ceasing to hold) and the one under concern now (Indices), we are confronted with the following oddity: suppose a law C(F, G) from 2.3.3.2 stops holding once in a while. What, now, is the crucial difference for laws of kind C(F∧@©(x, y, z, t), G) that *per se* do not hold at some space-time points? The difference that springs to mind is that where, according to the reasoning of 2.3.3.2, C(F, G) can only stop for a certain period of *time* in the whole of the universe laws of the index kind can stop at both periods of *time* and at particular *places*. Yet, this dissimilarity hardly amounts to an essential difference. It would only make laws where C ceases to hold temporarily a special case of index laws: the C ceasing variety equals those index laws for which the index (x, y, z, t) is, spatially, the whole universe during a certain period of time.[19]

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[18] Having introduced the notation '@©(x, y, z, t)u' I could also start to write ∀u (Fu ∧ @©(x, y, z, t)u ⊃ Gu).

[19] We could note down the respective index law with 'C(F∧@©(t), G)', for example.

Yet, we can point out a seemingly more substantial difference between the two. C(F∧@©(x, y, z, t), G) states that three universals (or quasi-universals) stand in the relation C whereas only two universals figure in C(F, G).[20] The difference shrinks again, however, when we ask what the crucial divergence is between, say, the conjunctive law C(F∧@©(x, y, z, t), G) ∧ C(F∧@(x, y, z, t), G) and a strictly and eternally holding C(F, G). I think that the metaphysical difference between the conjunctive law and C(F, G) is rather contrived. Even more so if we consider that it is impossible to tell apart the empirical consequences of these two laws and that, as a consequence, the two are epistemically utterly indistinguishable.

Speaking of empirical significance, I have to mention yet another bizarre consequence the acceptance of C(F∧@©(x, y, z, t), G) could have: although C does not hold between F, @(x, y, z, t), and G, still, F-instantiations and G-instantiations could be correlated at the index (x, y, z, t) *by pure chance* so that the regularity $\forall x\ (Fx \supset Gx)$ holds after all in the whole universe. To use Armstrong's words: the accidental regularity at (x, y, z, t) might mimic the regularity that would be imposed by the higher-order relation of universals (cf. Armstrong 1997: 197). No doubt, epistemologically this is undesirable: there would be no way to detect that the law broke down at (x, y, z, t).

It can't be denied that a defender of Humean or empiricist metaphysics will find the above considerations rather contrived and might think that they show, yet again, how dubious anti-Humean metaphysics is.

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[20] The change of the number of places of relation C seems not to bother Armstrong. I can't find a quote where he explicitly states that C can change the number of places but, next to the standard example C(F, G), he mentions frequently laws with more than two universals (for example: "Any law of the F&H→…sort may itself be defeasible." (Armstrong 1997: 231))

2.3.3.4
SINGULARITIES (CANDIDATE 2)

In my general chapter on fundamental laws with exceptions I offered laws with singularities as candidates. How does Armstrong's theory of lawhood cope with singularities? One thing is clear from the outset: if they cannot be accommodated something must be wrong with Armstrong's theory because laws with singularities are considered to be kosher by actual science.

To begin the assessment, I must return to some features of Armstrong's theory. Armstrong's laws are relations between universals but for universals to exist they must be instantiated at least once. This is why functional laws pose a difficulty for Armstrong for they are likely to have uninstantiated values, that is, they involve uninstantiated universals. For this problem Armstrong proposes the following solution:

> Statements of uninstantiated laws become counterfactuals about what laws would hold if certain unrealized conditions were realized. Their truthmakers must be sought in the real or instantiated laws. (Armstrong 1997: 244)

> What we have in the case of functional law is […] a determinable law that governs a class of determinate laws. Sometimes there is, strictly, no determinate law for certain particular values falling under the determinable law, because the antecedent value is omnitemporally never instantiated. These counterfactual truths are supposed to supervene upon the actual, instantiated, laws. Given just the instantiated laws, the uninstantiated laws are entailed. (Armstrong 1997: 245)

My code of conduct so far has been not to criticise Armstrong's overall theory but simply to accept it as tenable. I aim to do the same in this case: I grant his solution for functional laws and I will merely ask whether it is of help when it comes to laws with singularities.

For those, Armstrong faces a twofold problem. First, there is no counterfactual telling us what would happen if the values were instantiated since the equations are undefined, they 'break down' for such values. In other words, the other real and instantiated values cannot serve as truthmakers for any singularities-counterfactual because an extrapolation leads to the breakdown. Second, the problem here is not, as in Armstrong's quote, that certain antecedent values are omnitemporally never instantiated. On the contrary black holes do exist. What is entirely unclear is, however, which universal is instantiated at their heart (if any).

In principle, Armstrong could answer that, hence, Einstein's field equations cannot reflect the real laws because they do not fit into his metaphysical system. Yet, if we take this answer for granted we would have metaphysics dictating physics and that is, for a fervent naturalist or an "*a posteriori realist*", as Armstrong calls himself, hardly acceptable. Compare, for example, his claim: "It is to natural science, then, that we should look for knowledge, or perhaps just more or less rational belief, of what universals there are." (Armstrong 1997: 25)

Again, I have to close with an only partially positive and conditional conclusion: it is not entirely clear how Armstrong can incorporate singularities into his theory of laws. That he has to find a way is, however, indisputable because he wants his metaphysics to be in accordance with physics.[21] If he achieves this aim then laws with singularities (i.e., fundamental laws with exceptions) are acceptable for his theory of lawhood.

2.3.4 Do we Avoid the Epistemic and the Probabilistic Trap?

In my introductory chapter on fundamental laws with exceptions I spoke of two traps which must be avoided when one aims to formulate candidates for the possibility of laws with real exceptions: the epistemic and the probabilistic trap. The first says that candidates for laws with

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[21] I should add one caveat: in case a future theory, quantum gravitation, for example, proves our present theories to be wrong and, moreover, has a story to tell about what goes on at singularities then Armstrong could be off the hook by pure luck.

exceptions should not be strict laws in disguise—that is the case if it is possible to add exclusion clauses to the antecedent of the respective general statement. The second says that the candidate should not turn out to be a probabilistic law.

I argued above that Armstrong's own suggestion for laws with exceptions, namely defeasible (or oaken) laws are metaphysically not in a good state. I have excluded them from the list of candidates for laws with exceptions. Should singularities be acceptable into Armstrong's theory despite my doubts then they will *per se* escape the two traps because of the arguments I gave in chapter 2.1.

Now, do the two acceptable candidates from 2.3.3.2 and 2.3.3.3 escape both traps? Without any doubt! The epistemic trap is trivially avoided: we are indisputably talking metaphysics when introducing the gappy C(F, G) in 2.3.3.2, or 2.3.3.3's C(F∧@©(x, y, z, t), G). The probabilistic trap is also avoided. In order to see this, however, I need to spend some time on Armstrong's theory of probabilistic laws.

Probabilistic Laws. Armstrong's theory of probabilistic laws is that—as opposed to deterministic laws where we have "a state-of-affairs type that ensures, determines or necessitates a further state-of-affairs type"—in the probabilistic case

> the first state-of-affairs type will give a certain objective probability (which presumably can be given some definitive value) that an instance of the second state-of-affairs type will be caused to exist in suitable relation to the first state of affair […] We can say that the antecedent state of affairs, as it is convenient to call it, has a certain propensity to bring about the consequent state of affairs. A 'deterministic' law can then be thought of as one where the propensity takes the value 1. (Armstrong 1997: 237)

In the light of my earlier discussion of what instantiations of C(F, G) are, I interpret Armstrong's quote above as saying that, in the probabilistic case, C(F, G) is only instantiated now and then (in a probabilistic fashion) as token-causation. The interpretation I discard is the following: C is always instantiated as token-causation but only probably leads to success. The next quote supports my choice:

> We are supposing that the law is one that is uncontroversially a causal law. […] What a probabilistic causal law gives us is not probabilistic causality but a certain probability that causation will occur, an ordinary causation which occurs whether the law governing the causation is deterministic or merely probabilistic. (Armstrong 1997: 238)[22]

Having settled the metaphysics, it is convenient to distinguish a sure fire C from a probabilistic C in notation. In (Armstrong 1983: 132) he establishes (N: P) (F, G) for the latter where P is to be replaced by the actual probability (a number between 0 and 1)[23] and (N: 1) (F, G), or, in the more recent notation (C: 1) (F, G), for the sure fire C.

The task of this section is to inquire as to whether the two candidates that come closest to laws with exceptions are properly distinguishable from probabilistic laws. Now that Armstrong's theory of probabilistic laws is laid out in front of us the case is quite clear. We have, on the one hand, the case from 2.3.3.2 from above: C(F, G) where C stops holding now and then. (More accurate, we now have to write (C: 1) (F, G).) And we have the case from 2.3.3.3: (C: 1) (F∧@©(x, y, z, t), G). Metaphysically, both cases are different from exceptionless (C: P) (F, G) (with $0<p<1$): in the probabilistic case the G instantiation might be missing although F is instantiated because the causation between the two is not instantiated although (C: P) (F, G) holds: "The positive cases will be ones where there is actual causation. In the negative cases there will be no causation." (Armstrong 1997: 238) In the two cases from 2.3.3.2 and 2.3.3.3, however, (C: 1) does *not* hold.

Again, we have the same epistemic bullet to bite which we encountered in earlier sections: empirically, via the F-G-patterns actually occurring in the world, we might not be able to distinguish the three cases. Still, the

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[22] He also says that "if the relation between F and G is (N: 1) then there logically must be necessitation in each singular case" (Armstrong 1983: 132) and in his later book that "causation that is law-governed, but where the law is probabilistic only, exists only when, as one may say, the state of affairs falling under the antecedent of the law 'fires', that is, the potential cause actually brings about its effect." (Armstrong 1997: 75)

[23] In his later *A World of States of Affairs* neither this notation nor a new one appears but I can see no reason why we should not use the derivative (C: P) (F, G,).

probabilistic trap is avoided as much as the epistemic trap is because the metaphysical difference is secured.

Finally, we can ask whether probabilistic laws can themselves be laws with exceptions. Both seems to be logically possible: (C: P) (F, G) could cease to hold during Δt as much as the original C(F, G) (this correlates with the option from 2.3.3.2); and (C: P) (F∧@©(x, y, z, t), G) seems imaginable, too (the option from 2.3.3.3).[24] This ends my investigations about the epistemic and probabilistic trap.

2.3.5 SUMMARY

In this chapter I evaluated four kinds of law candidates for Armstrong's theory of lawhood: 2.3.3.1 defeasible laws, 2.3.3.2 cases where C(F, G) ceases to hold, 2.3.3.3 index laws, and, finally, 2.3.3.4 laws with singularities. The concept of a defeasible law, i.e., Armstrong's own suggestions for laws with exceptions, turned out to be metaphysically controversial: it is not clear how we can conceptualise what happens in the cases where the law is defeated. Furthermore, a special group of alleged defeasible laws, the force laws, turned out to be strict (or iron) laws. Here, the exceptions or interferences Armstrong is afraid of have to be subsumed under those cases I have earlier called 'pseudo exceptions'. In short, alleged defeasible force laws fall into the epistemic trap I warned of.

In 2.3.3.2 I discussed the option to treat those laws as laws with exceptions that cease to hold for certain periods of time during the history of the universe. I have presented an argument against granting them the status of laws with exception: where C, the nomological relation, ceases to

[24] We could, furthermore, ask whether the fundamental probability with which causation occurs could change. If Armstrong believes that C, the relation between universals, could *per se* end to hold why should he not also believe that the probabilistic nomological links could change in their probabilities? I could not find an explicit remark in Armstrong's books backing up this conjecture but I believe it to be the natural consequence of his previous thoughts.

hold between two universals the law simply vanishes. There not being a law anymore is, however, different form the law having an exception. Unfortunately, the same kind of argument could be applied to laws of 2.3.3.3: index laws adopted to Armstrong's theory. However, I have also argued that it would not be completely misguided to speak (if loosely) of both cases as laws with exceptions.

Problematic are laws with singularities (see 2.3.3.4): it is not entirely clear to me how Armstrong can fit singularities into his metaphysics, that is, especially into his theory of universals.

PART III

NON-FUNDAMENTAL LAWS

3.1
NON-FUNDAMENTAL LAWS: GENERAL CONSIDERATIONS

This part of the book is dedicated to the attempt to give a characterisation of *non-fundamental laws*—i.e., laws about non-fundamental, complex objects—that guarantees the law status of these laws while it also allows them to have real exceptions. In other words, the characterisation of non-fundamental laws I am after has to put forward other law-sustaining features than universal strictness. I call, from now on, these two requirements the 'Law-Status-Constraint' (in short '**LS-constraint**') and, respectively, the 'Real-Exceptions-Constraint' (in short '**RE-constraint**'). Remember that I have, in the introduction to the chapters on fundamental laws, spoken of ingredient X which is, in addition to or in competition with universality, supposed to guarantee lawhood. The LS-constraint asks for ingredient X.

Another essential requirement to meet my goals is that the definition of non-fundamental laws has to be on the metaphysical end of the spectrum of possible definitions. A concept of non-fundamental laws that centres too much on epistemic features like, for example, the value for predictions, endangers my project to find real exceptions: if defined too epistemically the distinction between *pseudo* and *real* exceptions might well be blurred. I call the third requirement the 'Metaphysics Constraint' (in short '**M-constraint**'). Difficulties will be caused mostly by the first two constraints for, quite obviously, they pull in different directions. This is why I will allow myself to neglect the M-constraint in what follows. It will not, however, be forgotten.

As I have said earlier, there is no universally accepted catalogue of orthodox theories of non-fundamental laws like in the case of fundamental laws. This is why I will introduce my own two concepts: *grounded laws* and *emergent laws*. *Grounded laws* will be laws which derive from the underlying structures of the objects they are about and, so, also depend on the more fundamental laws about those underlying structures. As an example consider the laws of molecular chemistry which depend on specific molecular structures plus quantum-mechanical laws. Another way to formulate the quintessence of such grounded laws is to say that they meet the LS-constraint in that their law-status is inherited from what is going on underneath: it must be because of the underlying structure and, mostly, because of the underlying laws of this structure that these non-fundamental laws count as laws. Details are spelled out in the next chapter (3.2).

The alternative laws, *emergent laws*, are about non-fundamental objects no matter whether their regularity stems from or depends on the substructure of these objects and any underlying laws or not.[1] Therefore, the source of their lawlikeness, i.e., the way they meet the LS-constraint, has to be found somewhere else as well: I will apply David Lewis's theory for fundamental laws to the non-fundamental realm, that is, emergent laws belong to a system of statements which describes the class of phenomena it is concerned with (chemistry, biology, etc.) in the simplest and strongest way. Chapter 3.3 will spell out the details.

The features I have outlined here for my two theories of non-fundamental laws are supposed to mirror those of Armstrong's and Lewis's fundamental laws. Emergent laws, just like the original laws of Lewis's best system, get their law character from a horizontal coherent net of true universal statements, whereas grounded laws, just like Armstrong's fundamental laws, are anchored in a deeper reality: here substructure and underlying laws, there nomological necessity.

How about the RE-constraint for both types of laws, grounded and emergent laws? I will eventually claim that both grounded laws and emergent laws can tolerate exceptions. Unsurprisingly, the mechanisms

[1] The name 'emergent' shall, here, indicate that these laws arise on higher levels while they do not have the tight link to underlying structures and laws that grounded laws have. No other connotation is intended.

that make exceptions possible are different for both laws. As with Armstrong's theory, it is difficult to uphold that grounded laws can tolerate exceptions. The Lewis spin-offs, emergent laws, are very 'exceptions-friendly'.

3.2
Non-Fundamental Laws: Grounded Laws

3.2.1
Introduction

The plan for this chapter is as follows: after an initial outline of the idea behind grounded laws and their general features here in the introduction I will first give a prosaic and then a detailed formal definition.[1] I will then consider counterarguments which dispute the success of grounded laws, that is, arguments which challenge both their law status and the possibility for real exceptions. The rest of the chapter will dialectically move from counterarguments to necessary adjustments of the original definition, back to more flaws, and back again to re-definitions, etc. My final verdict will be modestly positive. Grounded laws can have real exceptions in two cases: either underlying fundamental laws have exceptions or underlying structures break down. However, the latter option will turn out to be controversial.

Groundedness originates from the idea that non-fundamental laws are about complex objects. The definition will say, roughly, that a law *Fs are Gs* is grounded *iff* Fs are objects with parts such that the object's being F and its being G both supervene on the properties of its parts and, moreover, the law *Fs are Gs* supervenes on the laws amongst the properties of the parts of the object.

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[1] For the general argumentation, however, the exact details do not matter and the prosaic definition serves well.

Regarding grounded laws, the prospect of the existence of real exceptions lies, *prima facie*, in both, (a), the existence of the underlying structure (a: the structure-option) and, (b) the underlying laws (b: the laws-option): if we, (a), influence the substructure of a particular F we perhaps influence the behaviour potential of this object and so we might challenge the law at that instance. I take grounded laws to be, in this respect, similar to dispositions with bases. If an object loses the basis for a disposition it also loses that disposition. If the ground for the grounded law is lost, so is the grounded law. Similarly (b) if the underlying laws on which the grounded laws are based have exceptions the grounded law might inherit these exceptions.

As an example, take laws governing the chemical reaction between complex molecules. If you could change the laws of atomic physics and/or you could modify the structure of the molecules you would change the laws applicable to that molecule.[2]

Let me also note in this context that for my considerations of grounded laws it is unimportant exactly which general theory of lawhood, that is, of fundamental laws, one adopts in the background.[3]

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[2] I am well aware of the fact that *that molecule* might not be the original type of molecule anymore after a structural change such that the grounded law which has only the untouched kind of molecule as its subject does not apply anymore and, hence, that law has no exception. I will discuss this issue later (see strategies 1 and 2, in chapter 3.2.7).

[3] An interesting further definition we could put forward (but which is not directly related to the purposes of this chapter) is the definition of *non-grounded laws*: a law *Fs are Gs* is *non-grounded* if objects that are F do not have a substructure, or, at least, if this substructure does not dictate whether the object is F, or G, or whether *Fs are Gs* holds. The basic laws of physics are most likely non-grounded laws in this sense. That does not, by the way, mean—as a matter of my definition—that they are the grounds for some grounded laws (laws of, say, chemistry). However, it is very hard to think of a fundamental law that does not have an effect on any higher level. If we so wish, we can re-define the notion of a *fundamental law* in terms of groundedness and non-groundedness in the following way (thereby we would reveal a hidden double meaning of *fundamental*): a law *L* is *fundamental* iff *L* itself is *non-grounded* but *grounding* of other laws. Despite this suggested definition I allow myself to use *fundamental* and *non-grounded* synonymously when no confusion can result. — Feynman, by the way, once asked about alleged fundamental laws "whether there is a deeper basis […] or

3.2.2 PREPARATIONS FOR THE DEFINITION OF GROUNDED LAWS

The definition of a grounded law, *Fs are Gs*, comes in three stages: step (GL0) postulates that the entities the grounded law is about, namely Fs and Gs, are structured entities, i.e., Fs and Gs have a constitutive underlying structure. Consequently, one could call F and G *structural properties*.[4] The substructure consists of parts which themselves have properties and stand in certain relations to one another. Usually, the parts' properties are more fundamental properties and relations than those of the F and G level. Moreover, the parts need not be atoms; they can have parts themselves.[5] It is also worth mentioning that, in the formal definition, I allow Fs and Gs to be multiply realisable so that different objects which are F (or G) can have a different number and a different kind of parts.

The second step of the definition of grounded laws, step (GL+), secures that the grounded law, *Fs are Gs*, inherits the law character from the more fundamental laws that govern the behaviour of the parts of the Fs and Gs. I thereby meet the LS-Constraint: the underlying laws secure the law-status of the grounded laws.

(GL+) formulates the dependence of the grounded law *Fs are Gs* on the laws governing the parts of Fs and Gs by the way of supervenience: the properties F and G supervene on the properties P_i of their parts so that, due to the laws amongst the P_i, *Fs are Gs* results as a supervenient fact.

However, (GL+) defines only sufficient but not also necessary

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whether we have to take them as they are." (Feynman 1992: 81) Feynman was specifically talking about the conservation laws of energy, momentum, etc. It is hard if not impossible to conceive of an ultimate empirical test which would decisively show that a particular law is non-grounded. Nature could turn out to be infinitely complex.

[4] In the sense of Lewis: "The atom has the *structural property* of consisting of a proton and an electron a certain distance apart". (Lewis 1986b: 68; my italics)

[5] Chemical properties and laws, although they are themselves grounded in physical ones, ground biological laws.

conditions for things being Fs and, consequently, Gs. I stipulate, additionally in a third step (GL-), that there are other possible substructures that are sufficient for Fs but that do not secure (together with the laws about the parts of these substructure) that these Fs are Gs as well. That is, (GL-) postulates, first, that these possibly non-G-sufficient substructures of Fs have at least some properties P_i* other than those P_i properties figuring in (GL+) and, second, that the supervenience relations between Fs, Gs, and P_i* (or a mix of P_i & P_i*), plus the subvenient laws governing the P_i* properties (or a mix of P_i & P_i*) do not secure that *Fs are Gs*.

Think, for example, of one of the P_i properties of (GL+) as the property of having a certain mass or charge or volume whereas P_i* is the (GL-) property of having a little less or more mass, charge, or volume. An F whose parts change from being P_i to being P_i* (from weighing 5g to weighing 5.5g, say) could still be an F, yet, due to the laws governing the P_i*s lose the property G.[6]

(GL-) is, of course, intended to make real exceptions to grounded laws possible in that it allows the internal structure of particular Fs to be such that they are not Gs, i.e., there are F instantiations which are not G instantiations. *Prima facie*, one should hope that with (GL-) one can meet the RE-Constraint.

By the way, that the M-Constraint is met, i.e., the constraint that the law concept to be developed has to be on the metaphysical side of the spectrum of possible definitions, should not need further argument. Basing definition items (GL0), (GL+), and (GL-) solely on underlying structures and laws should qualify them as metaphysical.

[6] Note, that there can also be changes amongst the parts of an F which neither affect its being F, nor its being G. These changes are changes which remain in the realm of the P_i properties.

3.2.3 DEFINITION OF GROUNDED LAWS

As specified, the definition of groundedness comes in three stages: (GL0) postulates underlying structures, (GL+) secures that the grounded law inherits the law character from the laws it is grounded in, and (GL-) makes exceptions possible due to possible changes in the internal structure of objects. *Fs are Gs* is a grounded law *iff*

> **(GL0)**
> For each x that is F at time t there are parts C_1-C_n such that x is composed of C_1-C_n (n=n(x), i.e., n can vary with each x).[7] There are various properties and relations P_1-P_m, P_1*-P_h* such that various C_i, and various composites of subsets of $\{C_1\text{-}C_n\}$ can have those properties and relations P_1-P_m, P_1*-P_h* (again, with m=m(x), h=h(x)). For example: $P_1(C_1)$, $P_2(C_1 + C_3)$, $P_3{*}(C_4, C_7 + C_3)$. There are laws L_1-L_k relating the various P_i and P_j*.[8]
>
> **(GL+) (substructures involving the P_i properties only)**
> Now, consider the following domain D:= {the *x*s; all the parts of the *x*s}. F, G, and P_1-P_m are defined on D, i.e., they are subsets of D, D^2, D^3, ... (It follows from (GL0)'s requirement that the P_js obey some laws L_1-L_k that not all logically possible P_1-P_m distributions are allowed.) On D, the set of properties {F, G} supervenes on the set of all the P_js $\{P_j\}$ in the following way: it is necessary that for all x_1 and x_2 with parts $x_1=C_1+... +C_{n(x1)}$ and $x_2=C_1'+... +C_{n(x2)}'$: if there is a total match for all P_i between $\langle C_1, ..., C_{n(x1)}\rangle$ and some permutation of $\langle C_1', ..., C_{n(x2)}'\rangle$ then $Fx_1 \equiv Fx_2$ and $Gx_1 \equiv Gx_2$ and (because of the laws amongst the P_j) $\forall x\ (Fx \supset Gx)$.[9]

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[7] The order of quantifiers is important. I say, in effect, that for every F there is a certain substructure; not: there is a substructure such that everything that has it is an F. This has two important consequences: (i) the multiple realisability of Fs and, (ii) , that Fs can *either* be realised by (GL+) *or* by (GL-) structures.

[8] Please note that there are, of course, many different ways in which macroscopic objects can be cut into pieces but that does not matter for my definition. All I am saying is that if there is a way to deconstruct Fs that fulfils (GL0), (GL+), and (GL-) then *Fs are Gs* is a grounded law.

[9] Again in accessible prose: (GL+) ensures that the properties F and G supervene on the P_j properties which are properties of the parts of objects that are Fs or Gs and *en passant* that the grounded law $\forall x\ (Fx \supset Gx)$ supervenes on the laws amongst the P_j.

(GL-) (substructures also involving the P_i* properties) Consider, again, the domain D:= {the *x*s; all the parts of the *xs*}. Next to the F, G, and P_1-P_m also the P_1*-P_k* are defined on D, i.e., they are also subsets of D, D^2, D^3, ... But now, {F, G} supervenes on the set of all the P_is *and* P_j*s {P_j*, P_i} in the following deviating way from (GL+): it is necessary that for all x_1 and x_2 with parts $x_1=C_1+\ldots+C_{n(x1)}$ and $x_2=C_1'+\ldots+C_{n(x2)}'$: if there is a total match for all P_i, P_j* between $<C_1, \ldots, C_{n(x1)}>$ and some permutation of $<C_1', \ldots, C_{n(x2)}'>$ then $Fx_1 \equiv Fx_2$ and $Gx_1 \equiv Gx_2$ and yet (note the difference that is supposed to make exceptions possible) $\neg\forall x\ (Fx \supset Gx)$.

3.2.4 AN EXAMPLE GROUNDED LAW, SOME POSSIBLE AMENDMENTS TO THE DEFINITION, AND AN EXCURSUS ON EPISTEMOLOGY

Let me give an example of a grounded law in order to exemplify (GL0), (GL+), and (GL-). In doing so, I will mention possible minor adjustments to the definition just given. However, so as to keep the definition simple,[10] I will not actually make these changes. I hope to neither brush aside nor to cover up any insurmountable difficulties which might result if I were to try to implement these alterations.

The law I want to consider as an example of grounded laws stems from biochemistry: to supply their cells with a continuous and adequate flow of oxygen vertebrates use two oxygen-carrying molecules: the proteins *haemoglobin* and *myoglobin*. Haemoglobin carries oxygen in blood, myoglobin facilitates the transport of oxygen in muscles. I focus on haemoglobin which shall be the main actor in the following example of a grounded law: oxygen (O_2) combines with haemoglobin (Hb) to form oxyhaemoglobin (HbO_2): $O_2 + Hb \rightarrow HbO_2$.

Now, what corresponds to F, G, and the various P-properties of the underlying structure in my definition of a grounded law? Everything to the

[10] I realise that, in the light of 3.2.3, there is some irony in this statement.

left of the arrow corresponds to F, everything to the right to G. That means particularly that Fs are not necessarily what we would ordinarily call a single object. An F can well be the complex body formed by the two molecules Hb and O_2 in a close enough spatial relation[11] (if liquids, energy, movement, pressure, etc. are needed to kick off the reaction then F also refers to them). This move is unproblematic because Fs (and Gs) are in any case supposed to be complex objects. Consequently, G corresponds to HbO_2 but if there are any by-products next to HbO_2, G refers also to those by-products.

It is, at this point, time to introduce the first suggestion for a reformulation. We might want to replace *Fs are Gs* by the more complex *if there is an F there is a G*. Relevant adjustments in the rest of the definition would have to follow. This step is important if the object which acquires property G due to the law is not identical to the object which is F. Likewise, time variables might have to be incorporated into the definition if there is a causal process in time from F to G.

Let me turn back to haemoglobin: here are some parts of the molecule and some of their properties and relations which qualify as P_is: from biochemistry textbooks we learn that

> the capacity of […] hemoglobin to bind oxygen depends on the presence of a nonpolypeptide unit, namely, a *heme group*. […] The heme consists of an organic part and an iron atom. (Stryer 1988: 144)

[11] Note that I do not intend to introduce any vagueness into the definition of a grounded law when I use formulations like ‘in a *close enough* spatial relation’. This is just my (and, as a matter of fact, everyone’s) ignorance as to what the close enough distances exactly are. However, that is an epistemic issue. I believe that, ontologically speaking, there are exact distances such that the reaction is assured (whether we know them or not).
It is also worth mentioning that I do not claim that for each law statement stating a grounded law we have to have knowledge about all the underlying mechanisms or all the specifications necessary. This is why I am immune to a critique which might claim that I would never be able to state all the relevant properties and relations of parts and their laws. In the concrete haemoglobin example I discuss, it is not important that completeness is out of reach for epistemic subjects. Having said that, it is delightful to hear that “hemoglobin is the best understood allosteric protein” (Stryer 1988: 143).

In more detail, the heme group is a complex web of various carbohydrate chains and nets. In the middle sits, surrounded by four nitrogen atoms, the iron atom. Next to the internal bonds to the nitrogen the iron can form the crucial loose association with oxygen:

> Each hemoglobin molecule contains 4 polypeptide chains, and each chain is folded around an iron-containing group called heme. It is actually the iron that forms a loose association with oxygen. (Mader 1993: 614)

Needless to say, the huge rest of the molecule also has a say in the character of the O_2 binding. There are overall four heme groups in each Hb molecule such that four O_2 molecules can be bound in total. In fact, the Hb molecule has the exciting feature of binding additional O_2 molecules better the more O_2 molecules have been bound already.[12]

The relevant laws amongst these sample P_is properties are, for example, the chemical or physical laws governing the bonding between O_2 and Fe and the rest of the molecule's subparts. Quantum mechanical laws tell us about these bondings.

Let me, hence, assume that the abstract (GL0) and (GL+) structures of my definition of grounded laws have found their real life counterparts. How about (GL-)? In order to make the (GL-) structure plausible it is valuable to note generally that

> the discovery of mutant hemoglobins has revealed that diseases can arise from a change of a single amino acid in a protein. The concept of molecular disease, now an integral part of medicine, came from studies of the abnormal hemoglobin causing sickle–cell anemia. (Stryer 1988: 143-144)[13]

An easier example than sickle cell anaemia (and hence the one I will use) for the structural change I need for definition item (GL-) is, however,

[12] Obviously, that does not hold anymore once four O_2 molecules are bound.

[13] The study of molecular diseases is now an integral part of medicine. Sickle-cell anaemia can lead to "infection, renal failure, cardiac failure, or thrombosis." (Stryer 1988: 164) The disease's name stems from the fact that "red cells from a patient with this disease will sickle […] if the concentration of oxygen is reduced." (Stryer 1988: 164) Important for my definition item (GL-) is that "*sickle-cell hemoglobin has between two and four more net positive charges per molecule than does normal hemoglobin*." (Stryer 1988: 165) and is, therefore, structurally changed.

yet another derivative of the normal haemoglobin: in *haemoglobin M* a

> defective subunit cannot bind oxygen because of a structural change near the heme that directly affects oxygen binding. […] Water rather than O_2 is bound at the sixth coordination position. (Stryer 1988: 170; the second part of this quote is to be found in the margin of the page as subtitle to figure 7-54)

That is, we have an example of a haemoglobin (Hb) realiser (i.e., haemoglobin *M*) which does not combine with oxygen (O_2) to form oxyhaemoglobin (HbO_2). Translated into (GL-) this reads: haemoglobin M, our specific F, is realised by parts which have P_j* properties (rather than P_is) and the laws amongst those properties do not secure that this F is G. With an instance of haemoglobin M the sample grounded law has, so it seems, a real, not only an apparent, exception. The law's effect, Hb binding O_2 is not just masked: in this case, haemoglobin really does not bind O_2.[14]

It is likely that my example reveals already some of the difficulties that the concept of grounded laws and their exceptions will have to face. For example, one might ask why the original law does not read '*normal or non-deviant haemoglobin binds O_2*'. I come to this and other challenges in the sections following 3.2.6, especially in 3.2.8.

Excursus on Epistemological Issues. I would like to add two brief remarks on the epistemology of grounded laws to point out that these issues do *not* amount to challenges to grounded laws. (i) Admittedly, the concept of a grounded law is a bit remote from epistemological concerns. Note, for a start, that even if we know that *Fs are Gs* is a grounded law we might not be familiar with the underlying mechanisms. This, however, is no reason to reject the concept for it is meant to be a metaphysical notion. Compare, for example, theories of lawhood as formulated by Armstrong and Lewis. Neither of those theories presupposes that we know the laws that fall under their concept. (ii) A trickier point is this: suppose there is the grounded law *Fs are Gs* with well defined F and G. Yet, the concepts scientists (or laymen) actually use are the vague concepts F* and G* which

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[14] On top of haemoglobin M there are over a hundred more deviant forms, not to mention all the unclassified haemoglobin molecules which are altered or damaged by x-rays, radicals, etc.

might be more or less inclusive than the concepts F and G. Still, *F*s are G*s* comes close enough to the truth to be a useful generalisation. As a consequence, however, it will also be vague, seen from the perspective of epistemic subjects, whether the generalisation *F*s are G*s* has an exception or not in certain cases. There might, for example, be space for a dispute whether the object that unexpectedly turns out not to be a G* was, after all, an F* or not.

3.2.5 COMPARISONS

Next to examples of grounded laws like the one about haemoglobin, comparisons to similar ideas found in philosophy of science might help to shed more light on the concept of grounded laws. Compare, for example, Cartwright's model of a *nomological machine* to the concept of a grounded law. 'Being an F' and 'being the nomological machine F' (a carburettor, for example) share the same roots:

> What is a nomological machine? It is a fixed (enough) arrangement of components *[MAS: my C_1-C_n with properties P and P*]*, or factors, with stable (enough) capacities *[MAS: my sub-laws of those parts]* that in the right sort of stable (enough) environment *[MAS: i.e., if the underlying structure is not altered]* will, with repeated operation, give rise to the kind of regular behaviour that we represent in our scientific laws. (Cartwright 1999: 50).

The difference between Cartwright's idea and mine is that I avoided talk of dispositions and related concepts (powers, capacities, etc.) and spelled out in terms of supervenience how we have to imagine a "fixed (enough) arrangement of components".

As well as Cartwright, also Schurz and Glennan have introduced concepts similar to groundedness. Gerhard Schurz calls his grounded laws 'system laws':

> System laws […] refer to particular systems of a certain kind in a certain time interval Δt. They contain or rely on a specification of all forces which act within or upon the system x in the considered time

> interval Δt—the so-called boundary conditions. Examples of system laws in classical physics are Kepler's laws of elliptic planetary orbits, the law of free fall, etc.—almost all laws in physics textbooks are system laws. In physics, derivations of system laws from laws of nature and boundary conditions are usually not possible without simplification assumptions. […] Because of their dependence on boundary conditions, system laws involve a certain portion of contingency. Nevertheless, they deserve the status of lawlike generalizations as well, because they support counterfactuals, such as "if you were to jump out of the window you would fall down", or "if this bird were to be hunted by a predator, it would fly away". (Schurz 2002: 367-8)

Stuart Glennan talks in his 'Rethinking Mechanistic Explanation' about underlying mechanisms:

> A number of definitions of mechanism have been suggested, but my preferred one is as follows: (M) A mechanism for a behavior is a complex system that produces that behavior by the interaction of a number of parts, where the interactions between parts can be characterized by direct, invariant, change-relating generalizations. […] Mechanisms consist of a number of parts. These parts must be objects, in the most general sense of that term. They must have a relatively high degree of robustness or stability; that is, in the absence of interventions, their properties must remain relatively stable. Generally, but not always, these parts can be spatially localized. A mechanism operates by the interaction of parts. An interaction is an occasion on which a change in a property of one part brings about a change in a property of another part. (Glennan 2002: 344)

> A mechanism underlying a behavior is a complex system which produces that behavior by the interaction of a number of parts according to direct causal laws. (Glennan 1996: 52)

Finally, I have to mention Fodor who has made an attempt to solve the problems of *ceteris paribus* clauses by reference to underlying structures. He develops his theory of *ceteris paribus* laws in his 'You Can Fool Some of the People All of The Time, Everything Else Being Equal; Hedged Laws and Psychological Explanations' (Fodor: 1991). Fodor limits his inquiry to psychological laws where the antecedent is an attitude or other functional mental state a person can be in. Yet, there is no space here to go into more details.

3.2.6
CHALLENGES TO THE CONCEPT OF GROUNDED LAWS

There are grave challenges to the idea of grounded laws and, also, the possibility of real exceptions although, *prima facie*, they are made possible by item (GL-). I will introduce these challenges now but I will also try to defend grounded laws and their alleged real exceptions. My final verdict will be that the *law status constraint* (LS-Constraint) is fulfilled while the *real exceptions constraint* (RE-Constraint) is only met by a subclass of grounded laws. Here, then, are the five crucial challenges:

(C1) Grounded laws aren't laws after all. A 'fundamentalist' could claim that grounded laws should, conceptually, not count as laws at all. Only the fundamental laws should count as such.

(C2) Grounded laws could have more negative instances than positive ones. What if most Fs are realised by (GL-) structures which do not secure the occurrence of Gs? Is it then still justified to call the grounded law a law? There is, indeed, no statistical normalcy claim in my definition of grounded laws so far. Even worse is to come:

(C3) Next to the grounded law *Fs are Gs* there might well be the contrary grounded law *Fs are non-Gs*. To lay bare the full power of this challenge I have to revert to some details of definition item (GL-). This item is there to secure real exceptions to the grounded law. To serve this purpose, it asks for F realisations that do not necessarily bring about Gs, i.e., in contrast to (GL+) those F realisations do not secure that *Fs are Gs*. Some of the (GL-)-realised Fs might be Gs some might not.

This cannot mean, however, that some token realisation of a certain (GL-) type does secure G while some other token of that very same (GL-) type does not. This would contradict the supervenience relation of Fs and Gs on their realisation basis. What it must mean is that some (GL-) types do, others do not bring about G when instantiated.

We can, thus, divide the (GL-) class into two subclasses. (GL-+) and (GL--): those (GL-)-realised Fs which do and those which do not bring about Gs. Yet, what, then, prevents us from subsuming (GL-+) under (GL+)? Consequently, what would be left in (GL-), namely (GL--), only consists of those substructures that make Fs not-Gs.

The obvious conclusion is that this redistribution of substructures could have been made in the first place so that, in the initial definition of grounded laws, all (GL+)-realised Fs are Gs and all (GL-)-realised Fs are not-Gs.[15]

Let us assume from now on that this has been done. A devastating flaw becomes apparent then: since (GL-) and (GL+) are symmetrical they can easily swap their roles. The result is that, next to the initial grounded law that *Fs are Gs*, we also have the contrary grounded law that *Fs are not Gs*. That runs surely contra to our intuitions about lawhood. Hence, we have another extremely hard bullet to bite if we want to defend grounded laws with real exceptions.[16]

(C4) It is unacceptably easy to create grounded laws from almost any two consecutive events. In the same way as a crude property-nominalism could suffer from an implausible abundance of properties, an account of grounded laws like the one I have introduced could lead to an overpopulation of laws. Here is a recipe for *law-making*:

Take any complex event you like. Now, remember the Matrix movies where events (mostly martial arts fighting sequences) are ‘frozen’ and movie cameras circle around these ‘event-sculptures’. Imagine you take such a 3D photo at a certain time of the event you have chosen. Point to this event-sculpture and baptise it with the name ‘F’. This naming is meant

[15] That is, in definition (GL-), we move from $\neg\forall x\,(Fx \supset Gx)$ to the stronger $\forall x\,(Fx \supset \neg Gx))$. This is, maybe surprisingly, the only change necessary to capture what has been said in challenge (C3).

[16] Gerhard Schurz formulates similar challenges when considering Pietroski and Rey’s theory of *ceteris paribus* laws. If the law character of their laws is supposed to be secured and a minimal determinism is presupposed then any exception we allow is not only an exception to the original law it is also an instance of a contrary *ceteris paribus* law to the original *ceteris paribus* law (cf. Schurz 2001b: 367). This is, more or less, my challenge (C3).

to be a Putnam/Kripke style paradigm case baptising: a reference to an archetypal F. Everything sufficiently *like that* shall also qualify as an F. Now, let the 3D film continue for a couple of seconds. See what happens next. Then take another 3D shot and call the respective event-sculpture G (and everything else sufficiently *like it*: again Putnam/Kripke at work). Assume, in the background, a minimal determinism. *Voilà*, a grounded law: *Fs are Gs*.[17]

(C5) An infinitely complex world. The fifth and last challenge is fascinating but I will dismiss it immediately for practical reasons: what if there are grounded laws all the way down, i.e., if the world is infinitely complex? This would not only be a burden for the empirical sciences. The definition of a grounded law would also be in danger because it relies on the law character of those more fundamental laws which are constitutive for it. But if those laws are again grounded there is no rock bottom on which grounded laws could ultimately build a foundation.

However, this danger for grounded laws is of concern for any theory of lawhood. Think of Armstrong's or Lewis' theories. It would not be clear on which level of complexity Lewis' best system could arise and Armstrong would unsuccessfully search for universals since, in such a complex universe, every property would be constituted by other properties; a feature Armstrong does not allow for universals.

For the reason that challenge (C5) is not a specific challenge to grounded laws, I will ignore it and simply assume, as many philosophers do who write on laws of nature, that there is a fundament in nature. However, the first four challenges have still their full force and I am going to discuss them consecutively.

[17] Note that this challenge has nothing much to do with the challenge philosophers who believe in nomological necessity put forward against radical Humean accounts of lawhood, namely, that any odd regularity, even strikingly accidental ones, could become laws on the Humeans' account. My law-making recipe differs radically in two respects: it presupposes underlying mechanisms and does, therefore, not pick any mere coincidence; and, secondly, it takes a single instance not a regularity as the seed for a law.

3.2.7 TRYING TO MEET THE CHALLENGES

Challenge (C1). I am left with four severe challenges to grounded laws. The first challenge, *No Laws*, disputes their law status by contrasting them with fundamental laws. I have three answers to this challenge:

Answer 1. Lie down with dogs, get up with fleas. Grounded laws inherit their law character from the underlying laws. When Fs are realised by (GL+) structures the grounded law even inherits natural necessity from its pedigree laws if we believe in this necessity. For the same reason grounded laws also support counterfactuals.

Answer 2 is an argument from scientific practice: chemistry, biology etc. are full of regularities as described in grounded laws (cf. haemoglobin). Derived laws like grounded laws are the relevant law candidates for those sciences.

Answer 3 is a bit lengthier then the first two answers. I will show that both David Lewis's and David Armstrong's theory of lawhood[18] grant certain sorts of derived laws, which are very much like my grounded laws, law status. My conclusion will be that if two of the most famous theories of lawhood accept the law character of derived laws I am in good company. I admit that my argumentation will be painted with broad brush strokes but I hope it still serves its purpose.

I first inquire into what *Lewis's stance* could be on grounded laws: a bunch of grounded laws would be neither a simple nor a very strong description of the whole of the world nor do statements of grounded laws refer only to perfectly natural properties. At best grounded laws involve natural kinds like tigers and haemoglobin but those are far from being on a par with Lewisean perfectly natural properties like, presumably, being an

[18] Regarding accounts of lawhood which invoke necessary connections between universals (like Armstrong's) let me point out provocatively that they could be described as a search for a ground for laws where—empirically—no such mechanism can be found. Fundamental laws are, in necessiterian accounts of lawhood, grounded laws where nomological necessity plays the role of the underlying mechanisms.

elementary particle. So, *prima facie*, grounded laws do not qualify as laws in Lewis's understanding and do, *a forteriori*, not qualify as possible candidates for laws with exceptions either.

But we encounter this negative result only if we grant grounded laws too high a status, i.e., as those law candidates taking part in best system competitions. This is, however, the wrong approach (at least until further notice; I will discuss later how this approach can be successfully amended): only the fundamental laws take part in best system competitions.[19] Yet, once the competition has been decided not only *the axioms*, i.e., the fundamental laws, but also *the theorems* of the best system deserve law status:

> A contingent generalization is a *law of nature* if and only if it appears as *a theorem* (or axiom) in each of the true deductive systems that achieves a best combination of simplicity and strength (Lewis 1973: 73; the second emphasis is mine)

> Laws will tend to be regularities involving natural properties. Fundamental laws, those that the ideal system takes as axiomatic, must concern perfectly natural properties. Derived laws that follow fairly straight forwardly also will tend to concern fairly natural properties. Regularities concerning unnatural properties may indeed be strictly implied, and should count as derived laws if so. (Lewis 1983: 42)

> By "laws" we might rather mean fundamental *or derived* laws: those regularities that would come out as axioms *or theorems* in an optimal system. (Lewis 1979: 55)

When Lewis spoke about derived laws that "follow fairly straight forwardly" from the axioms he had cases like Galileo's or Kepler's laws in mind which follow from Newton's law of gravitation. Admittedly derived laws like my grounded laws are more complicated. Still, I believe it is justified to say that grounded laws are theorems of fundamental laws: if Fs and Gs are defined via their substructure and if, due to the (fundamental) laws governing all parts of these substructures, it follows that Fs are Gs then the required entailment is given. Therefore, grounded laws are

[19] This is not quite the correct way to describe what is happening. Rather, systems containing grounded laws might compete but such systems should lose out to systems of fundamental laws quite quickly because they are much weaker and less simple.

respectable entities in Lewis's system: not as the racehorses for best system competition but as the burros doing the theorems' labour.

A good starting point to see whether groundedness of laws is a concept suitable for *Armstrongian metaphysics* is a section in Armstrong's *A World of States of Affairs* entitled "Complex Properties" (Armstrong 1997: §3.7, 31-38). There, he acknowledges the existence of one essential part of my grounded laws, namely structural or complex properties:

> Structural properties […] involve both properties and relations. […] The constituent properties and relations are instantiated by particulars that are proper parts of the particular that has the structural property. (Armstrong 1997: 32)[20]

Armstrong takes being methane as his example for a structured or complex universal (cf. Armstrong 1997: 34). My haemoglobin example is just a little more complicated but the examples are quite comparable:

> An ontological analysis of what makes this object a methane molecule has been given. The form of the analysis is this. It is *a conjunction of states of affairs*. […] In every case where a particular has a complex property (in this case the particular [*a*+*b*+*c*+*d*+*e*] having M—where M is *being methane*) this state of affairs is identical with a certain conjunction of states of affairs. (Armstrong 1997: 35)

Without further argument I consider Armstrong's structural universals to be sufficiently similar to the model of supervenient properties I introduced in my chapter on grounded laws.

The next step in my theory of grounded laws are grounded laws themselves. I could not find an exact match in Armstrong's writings. However, he acknowledges what he calls "*emergent laws*".[21] When he writes about *Logical Atomism*, a hypothesis compatible with, and even similar to his own theory in *A World of States of Affairs* he says:

[20] Note aside that Armstrong allows for the world to be endlessly complex: "It may *perhaps* be a contingent matter whether there are or are not simple universals in the world" (Armstrong 1997: 33). I touched that matter earlier but wondered, there, whether Armstrong would not need basic universals for his theory.

[21] Armstrong's emergent laws have little to do with what I will later call 'emergent laws'. That I have chosen the same name is a bit unfortunate but I hope no confusion will occur.

> It may be that the non-atomic particular *a*+*b* has the further *atomic* property H, although neither *a* nor *b* […] has property H. […] In this situation, perhaps, the molecular state of affairs *a's being F+b's being G+a's having R to b* nomologically ensures [*a*+*b*]*'s having H*. […] Other, more complex, scenarios could be devised. But it will be seen that Logical Atomism could in this way be made compatible with *emergent* laws, as the above law might well be. (Armstrong 1997: 153)

Now, the relation required for my grounded laws is not *emergence* but *supervenience*. The similarity of the two relations is that parts of a whole plus the parts' properties somehow bring about or are at least relevant for the properties of the whole. For both emergent and supervenient properties it is true that if the substructure of an entity changes so might the properties of the entity which emergent from or supervene on that substructure. The following quote underlines this fact:

> *Being a raven* ensures (more or less) *being black*. The terms do not pick out universals, although no doubt there are universals whose connection ensure the truth or near truth of the generalization. (Armstrong 1997: 242)

I take it, therefore, that we find all ingredients for my grounded laws in Armstrong's theory or, at least, sufficiently similar components.

I conclude my detour on Lewis and Armstrong by claiming that grounded laws are respectable law candidates against the accusations of challenge (C1).

Challenges (C2)-(C4). The second challenge, *More Negative Instances*, disputes the law status of grounded laws in a more sophisticated and specific way, namely, by pointing out that they could have more negative than positive instances. This is due to definition item (GL-) which ought to serve the purpose of making real exceptions possible. If we were to drop (GL-) the second challenge would be banned immediately.[22] In other words, challenge (C2) reveals yet again that the LS-constraint and the RE-constraint pull in different directions and it starts being questionable whether they can be fulfilled together at all.

The third challenge, *Contrary Laws*, aggravates the second challenge

[22] This holds for (GL-)'s original as well as for its amended form.

by pointing out that the negative cases, that is, the exceptions, instantiate their very own grounded law such that we end up with two grounded laws which are contrary to each other: *Fs are Gs* and *Fs are not Gs*. Again the trouble-maker is (GL-). In one way, this state of affairs is not a big surprise: surely, the occurrence of exceptional cases does not mean complete anarchy. Already Mill wrote, correctly,

> the disturbing causes have their laws, as the causes which are thereby disturbed have theirs. (Mill 1872: 330)
>
> "What is thought to be an exception to a principle" […] is always some other and distinct principle cutting into the former; some other force which impinges against the first force, and deflects it from its direction. (Mill 1843: 445; Mill is quoting himself, hence the quotation marks; MAS)

However, it is one thing to say that there are law-governed disturbing factors and another to say that in cases where the law has an exception a contrary law applies. So, again, we are faced with the dilemma that making real exceptions possible (meeting the RE-constraint) challenges the law status (the LS-constraint).

Finally, the fourth challenge, *It is too Easy to be a Grounded Law*, reveals that there could be an innumerable abundance of grounded laws. This is surely a blow to the law status (and hence the LS-constraint) of grounded laws. Challenge (C4) does, however, not stem from (GL-). Even if we were to delete (GL-) from the definition we would face this problem.

I will now present the first two of three strategies to meet all these challenges (C2)-(C4) together. The third strategy will emerge later when I try to correct the shortcomings of the first two methods.

Strategy 1: NATURAL KINDS ESSENTIALISM. We might be able to established a sorting mechanism for the class of grounded laws accepted so far. If we accept what its proponents, like Brian Ellis, call *scientific essentialism* (Ellis 2001) we could put forward the following four step argument: (i) There are *natural kinds* which (ii) possess some of their intrinsic properties *essentially*. (iii) Fs, as figuring in grounded laws, are natural kinds. (iv) (GL+) structures belong to the essentially possessed intrinsic features of Fs. Hence, it cannot be the case that most Fs are realised by (GL-) structures so that the grounded law has more negative instances. On the same grounds there cannot be any contrary grounded laws. Finally, the number of grounded laws which might be infinite according to challenge (C4) is limited by the number of natural kinds there are.[23]

That all sounds very well but appearances are deceiving. I will soon come to the difficulties NATURAL KINDS ESSENTIALISM creates. One obvious one I would like to mention here: with NATURAL KINDS ESSENTIALISM, we have an unexplained and, some might say, dubious metaphysical baggage to carry: the argument for this strategy relies on the strong and as yet undefended assumption that *there are natural kinds which possess some of their intrinsic properties essentially*. I cannot argue for this hypothesis here. All I can do is openly admit that it is a controversial presupposition and that Strategy 1 stands and falls with its truth. However, let me at least quote one of essentialism's chief proponent's arguments. Ellis's reason for believing, first, in the existence of natural kinds is his *no-continuum argument*:

> The distinctions between the chemical elements, for example, are real and absolute. There is no continuum of elementary chemical variety which we must arbitrarily divide somehow into chemical elements. The distinctions between the elements are there for us to discover, and are guaranteed by the limited variety of quantum-mechanically possible atomic nuclei. (Ellis 2002: 3)

Ellis's argument, second, for natural kinds possessing some of their intrinsic properties essentially relies on Putnam-Kripke considerations concerning direct reference and kind-membership (cf. Ellis 2002: 16-17). In any case, we still have Strategy 2 up our sleeve:

Strategy 2: NOMINALISTIC STRICTIFICATION. Natural kind essentialism has its nominalistic counterpart. Let a *strictification* be the process by which we split the class F into two classes, F^+ and F^-, so that F^+ refers to all Fs that have structures specified in (GL+) and F^- to those which don't. In other words, we create two subclasses of Fs which have

[23] Note that in order to meet challenge (C4) alone the acceptance of natural properties or natural kinds would be sufficient. The *essentialism* part of strategy 1 is only needed to avoid challenges (C2) and (C3).

structures specified in (GL+) and, respectively, (GL-) as substructure *by definition*. We can go one step further and claim that thereby we reveal that the initial alleged grounded law is just a (now falsified) law-hypothesis. By the strictification process we arrive at the strict laws *F^+s are Gs* and *F^-s are non-Gs* which were behind the previous speculation.[24]

This process could be motivated by the aim of meeting challenges (C2) and (C3). It can also be motivated simply by the urge to arrive at *strict* grounded laws. The method is, moreover, not philosophical *science fiction* but known scientific practice:

> If one should discover a body which, possessing otherwise all the properties of phosphorus, did not melt at 44°, we should give it another name, that is all, and the law would remain true. (Poincaré 1958: 122-3)
>
> Then we shall read in the treatises on chemistry: "There are two bodies which chemists long confounded under the name phosphorus; these two bodies differ only by their point of fusion." That would evidently not be the first time for chemists to attain to the separation of two bodies they were at first not able to distinguish; such, for example, are neodymium and praseodymium, long confounded under the same name didymium. (Poincaré 1958: 123)

A note aside: when using the method of nominalistic strictification we must in any case resist the temptation to define the subgroups F^+ and F^- by demanding that an x is an F^+ *iff* it is (or brings about) G (*mutatis mutandis* for F^-). This strategy would certainly succeed in strictifying the law but it would catapult the new law out of the realm of empirical science and make it an analytic truth. What an F^+/F^- is has to be defined via the substructure but never via G. It is then a matter of the underlying empirical laws that these substructures bring about G (or not G).[25]

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[24] Strictification is, in principle, possible unless we hit rock bottom: unstructured F atoms without a substructure.

[25] In a nominalistic mood, strictification is always open to us. However, it is at odds with the natural kinds approach introduced first. Suppose we believe in the existence of natural kinds. Then, if F is a natural kind, the nominalistic subdivision into F^+ and F^-, into Tigers$^+$ and Tigers$^-$, say, would be an unnatural move; one that does not count as carving nature at her joints. Yet, there are also subdivisions of natural kinds that can be regarded as natural: gold, for example, is not only Au 197 but also comes in the radioactive isotopes Au 185-196, 198-201, and 203.

I have already mentioned that Strategy 2, NOMINALISTIC STRICTIFICATION, can be motivated by the aim to solve both challenge (C2), *More Negative Instances*, and challenge (C3), *Contrary Laws*, and it deals quite well with this task: it creates laws about F^+ and F^- which neither have negative instances nor do they contradict each other. Yet, while Strategy 1, NATURAL KINDS ESSENTIALISM, deals also well with challenge (C4), *Too Easy to Make Laws*, this challenge cannot be tackled by NOMINALISTIC STRICTIFICATION. On the contrary, nominalism seems to endorse the increase of laws rather than to limit it.

Shortcomings of Strategies 1 and 2. Yet, there is a serious drawback to both strategies together: with NATURAL KINDS ESSENTIALISM as well as with NOMINALISTIC STRICTIFICATION we burn down the house in order to roast the pig: in either case the new grounded laws we arrive at do not allow for exceptions on the basis of structural changes and, so, we have missed the initial goal to find a kind of non-fundamental laws with genuine exceptions in this respect. Exceptions on the basis of exceptions of the underlying laws are, however, still possible. Yet, we lose one of the ways to meet the RE-constraint.[26]

Where do we go from here? My suggestion is to try to amend NATURAL KINDS ESSENTIALISM so that we can overcome its shortcomings. Remember that this strategy is not at all bad: it meets all the initial challenges (C2)-(C4). The drawback of NATURAL KINDS ESSENTIALISM is not that the whole concept of a grounded law is in danger but only that grounded laws—hardened by NATURAL KINDS ESSENTIALISM—lose one valuable way of having real exceptions: structural changes. So, grounded laws amended by NATURAL KINDS ESSENTIALISM do not serve their purpose optimally.

Maybe a slightly weaker approach, formulated on the basis of NATURAL KINDS ESSENTIALISM, can achieve the original goal. This is what I discuss in Strategy 3 below. I take it, on the other hand, that neither the second strategy from above, NOMINALISTIC STRICTIFICATION, nor an

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[26] That is, the grounded laws' capital is now solely based on inheritance rather than on their own merit.

amended version thereof is apt to do the required job to our satisfaction. This is because this strategy not only fails to allow for exceptions by structural changes but, remember, it also leaves challenge (C4) unanswered. As a consequence, it is not even clear whether NOMINALISTIC STRICTIFICATION fulfils the LS-constraint. If there are too many laws (that's what challenge (C4) says) the concept of grounded laws is somehow inflated.

Strategy 3: NATURAL KINDS NORMALITY. Here is a new approach on the basis of strategy 1: keep the natural kinds but replace the honorific *essential* by the ordinary *normal*.[27] That is, demand that Fs possess the positive underlying structures (GL+) *normally*, not *essentially*.[28] (GL-) structures, on the other hand, should only be possessed *abnormally*. This breaks the symmetry between (GL+) and (GL-) and the alleged contrary grounded law *Fs are non-Gs* from challenge (C3), *Contrary Laws*, has, after all, no law status. Moreover, challenge (C4), *Too Many Laws*, is still banned because we keep the natural kind idea. I also claim, but I will still have to prove in the next section, that we escape threat (C2), *More Negative Instances*, for a huge class of grounded laws. Note that, with NATURAL KINDS NORMALITY we still secure the possibility of real exceptions (the RE-constraint) because Fs can be realised by (GL-) structures although they *normally* are not. So, the definition of grounded laws that includes reference to NATURAL KINDS NORMALITY seems to save both the law status of grounded laws (the LS-constraint) and, equally important for our purposes, the possibility of real exceptions.[29]

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[27] However, a defender of NOMINALISM need not be offended by the fact that I reject NOMINALISM as a good strategy. Although I presented strategy 3 as a weakening of ESSENTIALISM one could also see it as a strengthening of NOMINALISM: the acceptance of natural kinds or properties (without essentialism) is not the worst kind of concession for the nominalist to make and the now to be introduced NORMALITY is in coherence with NOMINALISM.

[28] Or, at least parts of the underlying structure. As long as there is *some* liberation from ESSENTIALISM strategy 3 will be successful.

[29] A note on epistemology: of course one can mistake an *abnormal* F for a normal one. Thereby one might fail to predict this Fs behaviour correctly.

Normality. Yet, we have smuggled in a bad black box into the theory: *normality*. How is normality going to be defined? Before I give a tentative answer, note that the *normally* I have invoked here is not a synonym for the *ceteris paribus clause* many philosophers theorise about when they try to make sense of *ceteris paribus* laws. I do not answer the question what a statement like 'Fs are Gs, *ceteris paribus*' means (for any kind of law) by answering that it stands for 'Fs are normally G'. That would be to explain the obscure with the obscure. My aim is different, namely, to introduce a concept of non-fundamental laws which allows the laws that fall under this concept to have *real* exceptions. And it is for this notion that I need a concept of normality.

Fortunately, there is a satisfying characterisation of what 'normally' could mean to hand. In his article 'What Is 'Normal'? An Evolution-Theoretic Foundation of Normic Laws and Their Relation to Statistical Normality', Gerhard Schurz (Schurz 2001a) has based a definition on evolutionary selection. Roughly, and adapted to my terminology and theoretical background, it goes like this: Fs have been selected through an evolutionary process which favours (GL+) structures over (GL-) structures. In more detail, (GL+) structures in Fs have been selected precisely because of their ability to produce G which is an ability that endows Fs with evolutionary advantages, i.e., with better survival chances. In his article, Schurz also shows that normality, understood in this way, implies a statistical push towards positive instances, i.e., there are many more (GL+) F instances than (GL-) instances. This is not surprising if (GL+) realised entities have better survival chances than (GL-) realised entities. It is here where the still missing argument can be found that answers challenge (C2), *More Negative Instances*: normal Fs are simply in the majority.

The Costs of Normality. NATURAL KINDS NORMALITY does not come without cost, though. Normality defined via evolutionary processes applies only to Fs which have an evolutionary history and these are essentially only biological Fs.[30] If we are lucky we can make a good claim for

[30] And some kinds of human-made devices and self-regulatory systems: computers, cars, central heating. It is, however, not clear whether we would want to call the

neurophysiological and some psychological laws that include biological kinds like human beings.

Still, NATURAL KINDS NORMALITY does not serve its purpose for other kinds of laws. Which story do we tell about, for example, chemistry or about complex physical structures and their grounded laws?[31] Unless we find a concept like normality also for those laws which is less strong than essentiality we seem to be forced to fall back onto strategy 1: NATURAL KINDS ESSENTIALISM.

How bad would that be, though? Well, as we know, the grounded laws of those sciences would then be strict (provided the underlying laws are). Luckily, this consequence is in accordance with our experience with these sciences. Think of water: nothing but (several *mol* of) H_2O qualifies as water. A molecular change would leave something else behind. Yet, this something else would not constitute a falsification to the grounded laws about water precisely for that reason.[32] On this basis, Strategy 2's NATURAL KINDS ESSENTIALISM seems anyway to be a better choice for chemistry than NATURAL KINDS NORMALITY. A vice has turned into virtue.

Consider my haemoglobin example from above. Which strategy do we apply, ESSENTIALISM or NORMALITY? Haemoglobin and creatures which have it certainly have an evolutionary history. Creatures whose oxygen

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respective regular behaviour of these devices laws. They are, after all, about *cultural kinds*, not *natural kinds*.

[31] Another baffling question to be answered concerning biology is how we deal with evolutionary shift and development. Biological grounded laws would shift with the natural kinds they are about and so also undergo evolutions. I admit not to have a good answer to this difficulty. (Brian Ellis even takes evolution to be a decisive reason to dismiss biological categories from the realm of natural kinds. He only accepts the stable chemical kinds (cf. Ellis 2002: 28-32; esp. 29: "There are many good reasons to believe that the biological species are not natural kinds." If we agree with this, biology has no grounded laws.)

[32] I admit that the situation is not as clear cut as I would like it to be. Deuterium D_2O and tritium T_2O might also qualify as water. If they do there are realisations of water which have minimally different chemical properties (for example, their density, freezing and boiling point are slightly higher). I guess what we are left behind with is different laws for D_2O, T_2O, and H_2O.

supply was optimal had higher survival chance. Hence, talking of *normal* haemoglobin would be admissible. It would also cohere with scientific practice: haemoglobin M (see above) and other deficient derivatives might well be called 'abnormal forms' of haemoglobin.

3.2.8 Farewell to Real Exceptions on the Basis of Structure Changes?

Where do these considerations leave us? Natural Kinds Essentialism was too strong because it left only one chance for real exceptions to grounded laws: only if the underlying laws have exceptions can their grounded ancestors have exceptions as well. Now we have seen that the strategy which seems to allow grounded laws to have real exceptions on the basis of structural changes, Natural Kinds Normality, does only apply to some grounded laws: those which involve entities that have an evolutionary history.[33] Regrettably, there is yet another potential shortcoming of Natural Kinds Normality.

My suggestion for the amendment of the initial characterisation of grounded laws with the help of Natural Kinds Normality was to add the following requirement into the definition: *Fs are Gs* is a grounded law *iff* Fs are natural kinds which possess (GL+) substructures *normally*. In this way, Natural Kinds Normality seems to provide some grounded laws with the ability to meet the RE-constraint in virtue of structure changes: should a (GL+) structure break down and become a (GL-) structure.

However—and this relates back to a recurring worry in this book—nothing prevents us from taking the *normally* out of the definition of a grounded law (from the (GL+) part) right into the grounded law statement itself so that it reads in the first place: *Normal Fs are Gs* is a grounded law

[33] That is, if normalcy can only be cashed out in evolutionary terms.

iff… For example, we could have: *Normal Haemoglobin binds* O_2.[34] In this way, my sample law turns out to be strict after all. Haemoglobin M would not be an exception for this grounded law because haemoglobin M is not a normal kind of haemoglobin.

This move combines aspects of the first two strategies, NOMINALISM and ESSENTIALISM. NOMINALISM enters the stage in so far as we change from *Fs* to the relevant class of *normal Fs*. Compare this to the change from 'Fs are Gs' to 'F^+s are Gs' in NOMINALISM. ESSENTIALISM plays its role in so far as normal Fs have the (GL+) substructure essentially: if normal Fs lose this substructure they are not normal anymore. Therefore, whether we chose ESSENTIALISM or NORMALITY, strictness for grounded laws (when the underlying laws are strict) seems to be the result.[35]

Suggestions for laws with exceptions in earlier chapters (cf. 2.1.3, 2.2.4, 2.3.3.2, 2.3.3.3) had to face similar challenges. Remember that index laws are, after all, represented by strict universal statements and that in Armstrong's theory we could speak of lawless situations rather than of exceptions to laws. Luckily, there were some ways to defend the stance that we encounter laws with exceptions nonetheless in these cases and, luckily, there are some ways to defend exception ridden grounded law as well. The arguments I will present are, however, not entirely decisive. I confess that the most they can achieve is to make plausible that it would not be too outrageous to speak loosely of exceptions to grounded laws.

The first argument is this: I said above '*nothing prevents us* from taking the *normally* out of the definition of a grounded law […] right into the grounded law statement itself so that it reads in the first place: *Normal Fs are Gs*.' However, that *nothing prevents us* does not mean that *there is*

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[34] The formal definition of a grounded law has to be changed accordingly. Basically, definition item (GL-) and the reference to the properties P* has to disappear.

[35] Note aside that this overall negative outcome would not depend on whether the concept of normality which I have borrowed from Schurz is tenable or not. If not, the idea of a grounded law can at best be sustained with the help OF NATURAL KINDS ESSENTIALISM and thus would equally only allow strict grounded laws. Also, if a definition of normality can be found without reference to evolution and so be applied to more basic sciences than biology as well, we still would end up with strict laws for those sciences due to the idea to take the 'normal' right into the law statement.

something that forces us. We could, so the defence continues, equally well leave the *normally* out of the law statement if we so decide. To stick to my example: *either* we say that 'haemoglobin binds oxygen' is a grounded law which has exceptions for abnormal haemoglobin *or* we say that 'normal haemoglobin binds oxygen' which is a strict law. I believe that scientists are more inclined to say 'haemoglobin binds oxygen' and to acknowledge exceptions.[36]

I come to the second argument in favour of the interpretation that counts structure changes with the respective consequences as exceptions. This argument has some weight even if we adopt the formulation '*Normal* Fs are Gs'. Suppose a certain object which is involved in some law governed process starts of as the promising *normal F*, that is, a (GL+) realised object. However, suppose furthermore that the relevant object's substructure is altered spontaneously due to some external inferences just before G comes about.[37] That is, the object's substructure breaks down during the relevant process. Now, the persistent defender of the formulation '*Normal* Fs are Gs' will, of course, still claim that the respective law has no exception because, strictly speaking, the law talks about normal Fs that are (GL+) realised *throughout*. Yet, I believe that we might also push for the intuition that the law has an exception in such a case.[38]

Although I do not offer a definite conclusion I hope to have unfolded the possible interpretations there are. I leave it to the reader to decide

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[36] I should, however, not withhold a minor argument for the 'strictification' of the law. Someone could argue that even if strictness is not a necessary requirement for lawhood we should insist that it is a strong desideratum. If we can get it for free then we should grasp it, i.e., of the two almost equivalent formulations above, the one which has the law strict should be our choice no matter what scientific practice is.

[37] This scenario might remind us of so called 'antidote cases' in the literature on dispositions.

[38] It might even be possible to target this argument at earlier formulations of grounded laws that favour ESSENTIALISM or NOMINALISM: while the relevant object starts as an F (or F^+) that is essentially (GL+) realised it might lose this structure during the process of becoming G. The object is, then, strictly speaking no F (or F^+) anymore but since it started as such we might still want to regard this incident as an exception to the law.

which one is correct. It is also important to underline again that even if the shift of the word 'normally' does secure strictness in so far as the stability of the substructure of normal Fs would be secured, it is still possible that the underlying laws could be laws with genuine exceptions. In such a case even the 'normal Fs are Gs' law can be a grounded law with exceptions.

3.2.9 PROBABILISTIC UNDERLYING LAWS

Grounded laws can inherit exceptions from their underlying laws. If an underlying law 'does not deliver', then the workings of the substructure might be affected in such a way that the derived law has an exception. There is a second way in which the underlying laws could *fail to deliver* once in a while: they could be probabilistic. This is a possibility I have not yet considered.

One reaction might be to say that we have, hence, another way in which grounded laws can have exceptions but strictly speaking this would not be correct. If the grounded law were blind as to what happens underground then on the surface both cases would seem equivalent. However, laws are not blind. Metaphysically speaking we must acknowledge that as much as grounded laws inherit exceptions they also inherit chanciness from their underlying laws.[39] So, if the fact that the underlying laws are genuinely probabilistic has an effect on grounded laws then this effect is that the grounded laws are probabilistic as well. It would be false, however, to say that they have exceptions on that basis.

[39] As much as some microscopic exceptions of the underlying structure might not have effects on the derived level so might probabilistic effects not make their way to the surface.

3.2.10 SUMMARY

This brings me almost to the end of my considerations of grounded laws. Here's a quick reminder of the torturous path.

From the outset grounded laws appear to be very good candidates for my purposes because they seem to have two possible ways to accommodate exceptions: the underlying structure of the objects concerned could break down or the underlying laws could have exceptions. However, there are a few challenges to be met: (C2) grounded laws could have more negative instances than positive ones, (C3) next to the grounded law *Fs are Gs* there is always the contrary grounded law *Fs are non-Gs*, and, finally, (C4) it is unacceptably easy to create grounded laws from any two consecutive events. (Here, I ignore the two less relevant challenges (C1) and (C5).)

I have introduced three strategies to meet the remaining three challenges. NOMINALISTIC STRICTIFICATION could counter (C2) and (C3) but not (C4) and so was disqualified as an appropriate strategy. NATURAL KINDS ESSENTIALISM solves all the problems but also robs grounded laws of the possibility to have exceptions on the basis of substructure changes (that does also hold for NOMINALISTIC STRICTIFICATION).

The third strategy, NATURAL KINDS NORMALITY, was meant to be weaker than ESSENTIALISM and NOMINALISM. So, my hope was that it preserves the possibility of real exceptions whilst still meeting the challenges. And yet, even this strategy turned out to be limited in scope because the evolution based notion of normality is only applicable to entities with an evolutionary history. Also, a reformulation of the initial law statement, '*normal* Fs are Gs', could make the law strict. I have argued that we can but do not have to go this route, so that NATURAL KINDS NORMALITY might still be an acceptable candidate for laws with exceptions.

3.2.11 EXCURSUS: GROUNDED LAWS AND THE ISSUE OF *CETERIS PARIBUS* CLAUSES

In this section I explore whether the idea of grounded laws can be helpful for the issue of *ceteris paribus* laws as it is usually discussed.

A once promising solution for the problems of *ceteris paribus* laws (for some of these problems see the introduction to this book) had to face serious counterexamples. Grounded laws might help to rehabilitate this solution. The account was given by Pietroski and Rey; the counterexample which I hope to disarm was put forward by Earman and Roberts.[40]

In their 'When other Things aren't equal: Saving Ceteris paribus Laws from Vacuity' (Pietroski & Rey 1995) Pietroski and Rey tried to spell out *ceteris paribus* clauses for laws by claiming that these clauses

> are 'cheques' written on the banks of independent theories, their substance and warrant deriving from the substance and warrant of those theories, which determine whether the cheque can be cashed. (Pietroski & Rey 1995: 81)
>
> These cheques represent a 'promise' to the effect that all [exceptional] instances of the putative law in question can be explained by citing factors that are […] independent of that law. (Pietroski & Rey 1995: 89)

I.e., Pietroski and Rey

> sketch and motivate a conception of cp-laws based on the idea that 'exceptions' to true nomic generalizations are to be explained as the result of interference from independent systems. (Pietroski & Rey 1995: 87)
>
> If there are no such interfering factors, then the apparent counter-example is a genuine one, and the putative law is false. Thus, cp-laws

[40] Independently, Gerhard Schurz has put forward a similar challenge in his 'Pietroski and Rey on *Ceteris paribus* Laws' (Schurz 2001b). Schurz and Earman and Roberts differ in that Schurz gives a formal and general approach to the subject which he applies to a whole group of attempts to spell out the *ceteris paribus* clause whereas Earman and Roberts refute Pietroski and Rey by the way of the counterexample given below.

> are far from tautologous on our proposal. […] However, on our view, the details of that commitment *do not need to be spelled out*: the second disjunct involves only *an existential quantification over interfering factors, and not a citation of the factors themselves*. (Pietroski & Rey 1995: 93)[41]

(The unwanted factors that interfere with a law will later be called 'H' and the relevant object x will be said to be H or be in circumstances H.)

Obviously, Pietroski and Rey do not differentiate between the two different kinds of exceptions I have outlined in Part I. By focusing on *predictions* with laws they seem to be able to cover both cases—pseudo and real exceptions—by the 'citation of independent factors'. In one respect, the failure to distinguish between the two kinds of exceptions does not do any harm, for whether the prediction goes wrong because the law's effect is really missing or just masked in both cases we have to demand that the exception "can be explained by citing factors that are […] independent of that law". Either those factors or interferers inform us about the masking or they tell us why it is that the law has a real exception.

However, next to the failure to distinguish between the two kinds of exception Pietroski and Rey also ignore the further difference between fundamental and non-fundamental laws. Yet, I will now explain how this second distinction—especially when we think of non-fundamental laws as grounded laws—can provide a remedy for the challenge from Earman and Roberts against Pietroski and Rey's theory.

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[41] Pietroski and Rey's general idea is, of course, not entirely new. Compare, for example, a passage in Elisabeth Anscombe's famous 'Causality and Determination': "This law of nature has not the form of generalizations running 'Always, if a sample of such a substance is raised to such a temperature it ignites'; nor is it equivalent to such a generalization, but rather to: 'If a sample of such a substance is raised to such a temperature and doesn't ignite, there must be a cause of its not doing so.' [...] It will always be necessary for them [i.e., statements beginning 'Always...', MAS] to be hedged about with clauses referring to normal conditions; and we may not know in advance whether conditions are normal or not, or what would count as an abnormal condition. [...] Thus the conditional 'If it doesn't ignite, then there must be a cause' is the better gloss upon the original proposition, for it does not pretend to say specifically, or even disjunctively specifically, what *always* happens." (Anscombe 1971: 94)

In their 1999 paper ‘Ceteris paribus, there is no Problem of Provisos’ Earman and Roberts found a counterexample to Pietroski and Rey's promising account. They showed that 'All spheres conduct electricity' comes out as a *ceteris paribus* law in Pietroski and Rey's analysis. Let, in 'cp: $\forall x(Fx \rightarrow Gx)$', *Fx* mean 'x is spherical' and *Gx* 'x is electrically conductive'. Now, some fact explains why a certain x is not conductive, for example, because that x has a certain molecular structure. Molecular structures are, however, explanatory independent from things being spherical or being conductive and hence, we have an independent factor *H* such that *Hx* explains $\neg Gx$:

> If Pietroski and Rey's proposal were correct, then it would follow that *ceteris paribus*, all spherical bodies conduct electricity. (Earman & Roberts 1999: 453)
>
> More generally, whenever any object's failure to exhibit property G can be explained by anything independent of whether the object exhibits property F, then Pietroski and Rey's proposal implies that *ceteris paribus*, anything with property F also has property G. (Earman & Roberts 1999: 453-4)[42]

So, do we have to give up Pietroski and Rey's account? I think not and Earman and Roberts themselves point in the direction of where to look for a remedy. They claim that Pietroski and Rey's account fails

> because [it] does not guarantee that F is in any way relevant to G, which surely must be the case if cp: $(A \rightarrow B)$ is a law of nature. Perhaps Pietroski and Rey's proposal could be modified to remedy this defect. But we do not see how to do this other than by requiring that the antecedent of the law be relevant to its consequent, in a previously understood sense of “relevant”. (Earman & Roberts 1999: 453-4)

Now, my account of grounded laws does precisely that: it shows that and how being F *is relevant* for being G (see GL+). Hence, we simply make it a precondition for a law candidate to be admitted to the *ceteris paribus* realm that it be a grounded law. Only on that basis can Pietroski and Rey's analysis start.

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[42] Note that Earman and Roberts’ counterexample is a variation of my challenge (C4) above.

Their independent interfering factors must then do either of two things: (i) show that the effect of the law was fully there after all, but masked, and explain how the masking was done, or, (ii) explain how the relevance of F for G—the mechanisms described in my definition of grounded laws (GL+)—was disturbed by the interference.

In any case, counterexamples like Earman and Roberts' pseudo sphere-law cannot succeed anymore because they fail the precondition to be a grounded law. Earman and Roberts wrote: “Perhaps Pietroski and Rey's proposal could be modified to remedy this defect […] by requiring that the antecedent of the law be relevant to its consequent, in a previously understood sense of ‘relevant’.” The previously understood sense of ‘relevant’ that I can offer is groundedness.

3.3
Non-Fundamental Laws: Emergent Laws

3.3.1
Introduction

There is a second way to define non-fundamental laws which differs from the theory of grounded laws. I will introduce what I will call '*emergent laws*' in what follows.

A brief general remark is helpful: whether the laws I will now introduce are grounded in or in any sense dependent on fundamental laws is an empirical matter. Some might be, some might not. Any lawful dependence on underlying structures is not guaranteed *a priori* by their definition. Consequently, these laws cannot gain their law character from any underlying structure and laws. Using the language of my introduction to Part III, the laws I am about to introduce will meet the LS-constraint (i.e., the law-status-constraint) in a way divergent from grounded laws. This chapter will also build a bridge to the more widespread considerations concerning *ceteris paribus* clauses in that it integrates a suggestion for a theory of these provisos.

3.3.2
The General Idea

Here is the basic idea: accept law candidates as rivals in Lewisean best system competitions as usual but organise separate competitions for each non-fundamental science: one competition for chemistry, one for biology, etc. depending on how far up you are willing to go. Each realm will provide its very own law candidates. Now, we cannot expect these special science systems to be as neat as the systems for the fundamental level are (or, to be more cautious, as we expect the system for the fundamental laws to be). The best system for biology might contain law candidates about, for example, tigers and their stripes which have exceptions for albino tigers. The hope is that a system containing such law candidates can still win the best system competition because it is unlikely that there are other, more advanced systems: no matter how hard we try there are no systems strong and simple enough with only strict regularities in biology.

Translating these considerations into the jargon I have introduced earlier (cf. chapter 3.1) we would say that the LS-constraint is supposed to be met by membership in the best system whereas the RE-constraint could be met by the fact that a best system competition might be won regardless of the patchiness of the woven net (see also the chapter on fundamental Lewis laws: chapter 2.2).

3.3.3 OBSTACLES

We encounter two obstacles **(O1)** and **(O2)** and one pleasant consequence (see 3.3.4) if we adopt this method of defining higher order science laws. The first obstacle, **(O1)**, concerns the competition rules. We have to suppose that it is possible to delineate chemistry from physics, biology from chemistry, etc. to run individual contests for different sciences. Yet, the borderlines between those sciences are vague and so are the criteria for membership of properties in one as opposed to another science. Moreover, laws of one science might well purposefully quote properties from other sciences. Take, for example, the biological (or medical) rule that humans cannot survive much longer than ten days without water (H_2O + certain isotonic salts).

In order to remove obstacle **(O1)** I propose the following ordering mechanism: subsume law L under science X if and only if (i) L quotes at least one property of science X *and* (ii) science X is highest up in the hierarchy of all sciences of which L quotes properties. The law about humans and their need for water, for example, qualifies clearly as biological law because *being human* is a biological property (and there is no further higher psychological or economical property).[1] Other criteria might be needed to sort out the competitions. The issue of vagueness, for example, is not yet resolved. However, I assume here (without pursuing it any further) that these issues are of a merely technical character rather than a matter of principle and, so, I move on to the second hurdle.

(O2): We need to spell out how exceptions should be registered in special science law candidates. First note that the index-law structure I have introduced for fundamental laws, $\forall u\,(Fu \wedge \neg @(x, y, z, t)u \supset Gu)$, is not the whole story because the exceptions we have to expect in non-fundamental laws are rarely restricted to certain space time regions.[2] Rather, they are often bound to certain individuals: take, for example, Bino the albino tiger. However, it seems possible to exclude those individuals in the antecedents just in the same way in which we have excluded indices. Yet, even if we accept this possibility a new twofold difficulty appears.[3]

First, the exclusion lists of individuals in the antecedents of law candidates would most probably be unmanageably long. Also, many if not most exceptions are unknown. Therefore, second, we do not in fact find

[1] In a more speculative mood we might start to wonder whether what we call physics is really just one level (the bottom level) or should rather be divided into several stages. The physics of, say, medium and large sized solid objects being the highest, quantum mechanics being the most fundamental level. Having divided physics in this manner we could check whether both the grounded laws approach and the approach I introduce here would come to the same conclusions as to what counts as a law for certain higher levels.

[2] Although there could be such examples: black swans seem to be a phenomenon endemic to the space-time region called ‘Australia’.

[3] I ignore for now difficulties from above, namely, that laws should not include references to individuals (cf. my chapter 2.1 on general considerations about fundamental laws with exceptions).

law statements of that kind in actual scientific practice.[4] Rather, the lawlike statements we come across in chemistry, biology, etc. often bear (implicit) proviso clauses like *ceteris paribus* but they do not explicitly list exceptional cases. Hence, my suggestion to characterise non-fundamental laws via Lewis's idea plus lists of exceptions seems to distort what is the actual practice in science. How do we get from the armchair into the lab?

3.3.4 EMERGENT LAWS AND THE ISSUE OF *CETERIS PARIBUS* CLAUSES

I will now show that there is actually no major gap. I even claim that my new characterisation of non-fundamental laws can solve some theoretical problems *ceteris paribus* clauses in law statements usually cause. This is the pleasant consequence I announced earlier for a Lewis system applied to the special sciences.

For a start note that when dealing with Lewis systems we are always supposed to be operating from a heavenly or, at least, metaphysical perspective (which is also in line with the project of this book: the Metaphysics of *Ceteris Paribus* Laws). To run the best system competition we can, so to speak, employ an omniscient being. She will have no problem comparing systems including law candidates with long lists of exceptional individuals excluded in their antecedent. (More importantly, she will have the complete world history in front of her eyes and know all exceptions to all regularities.) Doing so she will, hopefully, come up with one robustly best system. If not, not: as with fundamental sciences, the world—or the aspects of the world we are dealing with—could be too messy to have any laws (in this respect we do not divert from Lewis). After

4 Note that the considerations about indices in the case of laws from fundamental science were more or less of a theoretical character. Index laws do not appear in actual physics because nature has been sufficiently regular. In chemistry and biology, however, laws with exceptions might even be the standard.

the job has been done (with success I assume) we ask our divine helper to hand over the list of laws. However, and this is the fundamental clue which will help us to interpret provisos, not without asking her to perform some cosmetic surgery on our candidate laws: delete all the exclusion phrases of exceptional individuals from the laws' antecedents and attach, instead, the proviso clause '*ceteris paribus*' to these law statements.[5] This cosmetic operation is less superficial than it might seem: first, it translates the lengthy law statements that have participated in the contest into the law statements typical for the special science: law statements with proviso clauses. Hence, we have arrived from the armchair into the lab.[6] Second, we gain, as a side effect of the genesis of our laws, a proper theory of these proviso clauses. Let me explain.

As we know, proviso clauses in law statements are troublesome because these statements are in danger of turning out to be either tautologous or empty: 'all Fs are Gs, *ceteris paribus*' might say nothing more than 'all Fs are Gs, unless not' or than 'all Fs that are also … <here is a gap> … are Gs'. Now, however, we have a proper interpretation of the proviso clause: it serves as a reminder that the law, in its virgin form, listed exceptions in its antecedent when competing together with other laws for the best system status (balancing strength, simplicity, and fit ideally). That is, the proviso refers to, or, better, stands for the long exclusion list the original competing law statement incorporated. The novelty of this proposal is that it does not aim to define provisos solely in a law immanent way. Rather, provisos also have a holistic aspect transcending the isolated law: statements bearing provisos are abbreviations of those ideal statements (including the exceptions) which are part of the robustly best system. It is the membership in the best system that makes the proviso

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[5] Remember, that I do not use the *ceteris paribus* phrase in its literal meaning 'all else being equal' but in the vague, hand waving sense in which it is often used: 'beware, in certain exceptional cases this might not be the case'.

[6] There is another positive aspect of this step. It seems to be a rather contingent matter which individuals are exceptions to non-fundamental laws (think of the albino tiger who has a gene defect caused by exposure to random x-rays). Hence, with the introduction of the *ceteris paribus* clause we remove the reference to contingent matters of fact from the law statement.

clause acceptable.[7]

The theory also explains why the exceptional cases the provisos cover are often unpredictable and unknown to us, for not only do we not know the complete exclusion lists, surely, we also cannot really expect heavenly help when we do empirical science. Rather, the system the sciences presently operate with is a mere image of the ideal system. With a bit of luck, it approximates the divine original pretty well.

3.3.5 GROUNDING NOT FORBIDDEN

Before I applied Lewis's best system idea to non-fundamental sciences I said that the resulting characterisation of laws will not entail that they are grounded in the laws and properties of more basic sciences (in contrast to the grounded laws defined in an earlier chapter). However, whether you subscribe to a crude reductionism or you only believe in some looser connections between different levels, it is rather uncontroversial that there are some links and influences from, say, the physical realm to the biological.

Hence, we can hope that more fundamental sciences can make visible[8] both why the statements of the best system of a less fundamental science are true in their non-exceptional cases and also what has gone wrong when exceptions occur: the first because they can unearth hidden mechanisms; the second because they can also reveal when a mechanism has been

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[7] In a radical interpretation of this move a vice is turned into a virtue: the *ceteris paribus* tag can now be interpreted not as a weakening of a law but rather as a knighting of an almost general statement that gets the honour to be included in the best system. 'Ravens are black' is a mere factual and also false general statement. 'Ravens are black, *ceteris paribus*' shall, however, indicate both that there are exceptions but also that it is a law belonging to the best system to describe the biological world.

[8] I say cautiously 'make visible' rather than 'exhaustively explain' because it depends on what nature is like, i.e., whether reductionism/supervenience is true or not, and how successful we are with such explanation.

broken or is absent. Therefore, although exceptions might often be unpredictable they will, once they have occurred, not be unintelligible.

Returning to Pietroski and Rey (cf. 3.2.11), we can acknowledge that their metaphor of proviso clauses as "'cheques' written on the banks of independent theories" (Pietroski & Rey 1995: 82) applies very well to our scenario: for emergent laws the credibility of the 'proviso-cheques' is first and foremost guaranteed by the membership of the law in the best system but also by the law possibly being rooted in more fundamental sciences that explain which mechanisms or underlying structures are broken in exceptional cases.

3.3.6 DIFFICULTIES: REPRISE OF THEMES FROM THE GROUNDED LAWS CHAPTER

Grounded laws had to face severe challenges. I would like to go quickly over these challenges in order to test whether they also threaten the new type of non-fundamental laws just introduced.

(C1): The first challenge, *emergent laws aren't laws after all*, has some bite, especially when combined with the question whether emergent laws meet what I have called the M-constraint and which I have not yet tackled. In my introduction to the chapters on non-fundamental laws I demanded that any concept of such laws has to be more on the metaphysical side of the spectrum of possible definitions so that the distinction between real and pseudo exceptions is not endangered. So, is the concept of an emergent law what we can call a metaphysical concept? In one respect it certainly is. Remember that we have asked an omniscient being to have a look at the world history as a whole and decide on that basis which systems are describing certain aspects of this history best.

However, there is also a sense in which anthropocentric parameters enter and so make it questionable whether emergent laws are objective enough: the aspects under which our omniscient being had to view the world might be said to be chosen anthropocentrically. That is, the division into chemistry and biology could be one that is tailored to human interests and human intellectual dispositions (note that this division has to be made *before* the separate competitions start). However, the alleged laws are then not what we want laws to be: the objective rules nature comes equipped with by herself.

I hope that this description of the scenario is too exaggerated. After all, chemistry could be characterised as the science of the elements listed in the periodic table and the periodic table of elements seems not to be tailored to human interests but rather discovered. This table is nature's own inventory—it reveals nature and her joints. As for biology, it could be argued that self-organising entities which are subject to evolutionary processes are not human constructs either.

In combination with the idea that we appeal to an omniscient being doing the sorting of systems I hope that, despite the doubts, we arrive at a sufficiently objective notion of an emergent law so that their definition can count as a concept of non-fundamental laws more to the metaphysical end of the spectrum.

(C2): Could emergent laws have *more negative instances than positive ones*? This is very unlikely but I see one slight possibility: a statement could provide an extremely helpful taxonomy although there are more exceptions to it than it has positive instances.[9] Maybe it could make its way into the best system. Much depends on how simplicity, strength, fit and their balance are measured so that I do not dare to give a decisive answer.

(C3): The third challenge pointed out that in the case of grounded laws there could, *next to the grounded law Fs are Gs, be the contrary grounded law Fs are non-Gs*. Could that happen with emergent laws? That is, could a best system contain both a statement like *Fs are Gs, ceteris paribus* and *Fs are not Gs, ceteris paribus*? Intuitively, we surely want to deny this possibility on the basis that incoherent systems cannot be best systems. However, it is not so much *incoherence* as *anti-simplicity* which excludes

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[9] However, I should remind myself that I have excluded approximations and idealisations from my inquiry and I might, here, make the mistake to think of those.

the opposite *ceteris paribus* law. To see why, we need to have a look at the genesis of emergent laws. At the origin of the two alleged *ceteris paribus* law statements (before the cosmetic changes) stand the two candidates $\forall u\ (Fu \wedge (\neg u{=}a \wedge \neg u{=}b \ldots) \supset Gu)$ and $\forall u\ (Fu \wedge (\neg u{=}e \wedge \neg u{=}f \wedge \ldots) \supset \neg Gu)$ where the first candidate excludes all individuals which *are not* G when F and the second excludes all individuals which *are* G when F. Perhaps surprisingly, these two candidates are not as incoherent as our intuition about their descendents, the *ceteris paribus* laws, seemed to suggest. Rather, stating both law candidates together amounts in effect to listing each and every individual F and stating whether or not it is G. While such lists have a certain strength they are definitely not very simple. Therefore, there is justified hope that, on grounds of the lack of simplicity, danger (C3) is banned.

(C4): *Is it unacceptably easy to create grounded laws from almost any two consecutive events*? Certainly not! What the best system accommodates is limited by the simplicity constraint. A system that incorporates any kind of garbage is not simple enough to win the competition.

(C5): It seems that emergent laws are almost made to cope with the last challenge, *the world could be infinitely complex*: as long as we are able to single out different levels it does not matter how complex the world is because the nomicity of emergent laws is established horizontally, not vertically.[10]

Finally, I have to consider the challenge that has been recurring throughout the whole book: the candidate law statements that are competing in best system competitions are supposed to list their exceptions explicitly in their antecedent. However, that makes their linguistic representation a strict universal statement. (We encountered a similar oddity in my chapter on index laws). Even their beautified successors, the law statements with *ceteris paribus* clauses instead of deflated antecedents, are in one sense strictly true. However, to insist that the law 'All Fs are Gs,

[10] An infinitely complex world would, of course, be a problem if we were on the hunt for fundamental laws.

ceteris paribus' is a strict law because the statement is universally true would be very weird indeed. Here, I believe, focussing on the actual events or facts and their regular—or not so regular—patterns is much more sensible.

I think, therefore, that emergent laws deal fairly well with all the challenges and so I regard them as good candidates for non-fundamental laws with exceptions.

3.3.7 SUMMARY

I have, in this section, introduced a way to characterise laws of non-fundamental sciences on the basis of Lewis's best system idea. I have claimed that this theory can provide a solution for the problems proviso clauses pose for law statements of these sciences. The core idea is to run best system competitions for each non-fundamental science. The laws that compete, exclude all their exceptions explicitly in their antecedent. When the best system is found, however, the exclusion clauses are replaced by a typical proviso clause (*ceteris paribus*, for example). In this way, the proviso neither means 'unless not' nor does it simply hide unexplained gaps. I have also argued that certain challenges to emergent laws, including the objection that their statements are strict, can be met.

CONCLUSION

CONCLUSION

The goal of *The Metaphysics of Ceteris Paribus Laws* has been to answer the question whether we could have a tenable concept of laws of nature which allows the laws to have exceptions. *Prima facie*, it sounds impossible to achieve this aim because strict universality is thought to be a necessary condition for lawhood. However, it is also well known that universality is not sufficient to distinguish laws from pure universal accidents. Further criteria are needed and a multitude of additional defining features *X* for lawhood have been suggested. Yet, once it is acknowledged that universality is not *the* criterion for lawhood it is but a small step to question whether it is really necessary or just very important. The working hypothesis of my enquiry has, consequently, been this: it might be that some of the suggested *X*s (which are each at the heart of a different concept of laws) are strong enough to guarantee lawhood even if there are instances that do not conform to the law.

I have analysed four such additional features, i.e., four different concepts of lawhood. Two of them are concepts of fundamental laws—as characterised by David Lewis and laws as defined by David Armstrong—the other two concern the level of non-fundamental laws—grounded laws and emergent laws; my own conceptual inventions.

I have also distinguished two kinds of exceptions—one type concerning predictions with laws rather than the laws themselves; the other type being what we can justifiably call real exceptions to laws. The focus of my inquiry has only been the last type of instances that do not conform to the law (see chapter 1.1).

(i) After some very general considerations regarding the preconditions for the possibility of the existence of laws with exceptions (chapter 2.1) I have started the investigation of **Lewis style laws** (chapter 2.2). There are, so my conclusion, at least two possible ways in which these fundamental laws could tolerate exceptions: on the basis of singularities and on the basis of what I have called 'indices' (roughly: individual space time points where the laws do not hold). The official manner of speaking about singularities is that 'the laws break down at such points' so we have a relatively clear case of exceptions. It is, however, more controversial how to interpret laws with indices: although the antecedent of '$\forall u\ (Fu \wedge \neg@(x, y, z, t)u \supset Gu)$' is not simple, the whole proposition is nonetheless a strict universal law statement. However, if we focus on all the Fs and their behaviour rather than on linguistics, it is justified to say that we confront a law with an exception at (x, y, z, t).

(ii) Armstrong's concept of fundamental laws (chapter 2.3) has nomological necessity as the additional feature X for lawhood. I have argued that it is questionable whether Armstrong's own suggestion for laws with exceptions, defeasible laws, is tenable because the metaphysics of such laws is problematic. As shown, it is also a challenge to incorporate laws with singularities into Armstrongian metaphysics. There remain the index laws, C(F∧@©(x, y, z, t), G), as promising candidates and a close relative thereof (C ceasing to exist). However, we have to decide again (as in Lewis's case) whether we focus on the fact that C holds, after all, *strictly* between F, @©(x, y, z, t), and G, or whether we look "at the [corresponding] classes of lawful and outlawed events" (Lewis 1979: 55). If we do the latter, it seems again tenable to speak of a concept of laws that allows for real exceptions.

(iii) The concept of non-fundamental **Grounded Laws** (chapter 3.2) is my own invention. They receive their law-character from the underlying structures of the objects they are about and also from the more fundamental laws about those structures. Already from the outset, grounded laws seem to be promising candidates to be laws with exceptions: assume *Fs are Gs* is a grounded law, that is, assume that an F's substructure makes it also a G because of the underlying laws about this particular substructure. Now, the idea is that some individual F's parts might be damaged or altered so that it cannot be, or cause, G while it nonetheless counts as F. Such a case seems to be a tolerable exception to the law *Fs are Gs*.

However, I have given a multitude of reasons for why things are not as simple as they appear, and I had to launch several attempts to rescue the idea of grounded laws and their exceptions: in the end, there is just a small class of grounded laws left which indeed could handle instances that do not conform to the law on the basis of alterations of underlying structures.

There's a second possibility for grounded laws to face exceptions. Since these laws are not solely grounded in underlying structures but also in more fundamental laws a breakdown of the latter could cause a breakdown also of the dependent grounded laws: if macroscopic objects like Fs survive indices and/or singularities (see the possibilities for exceptions for fundamental laws above), then grounded laws could have exceptions at those spots as well.

(iv) The second type of non-fundamental laws, which I call '**emergent laws**' (chapter 3.3), is inspired by David Lewis's best-system approach, here applied to the non-fundamental level: for each science, find the simplest, strongest, and best fitting system of laws for that particular realm. Laws gain their law character from membership in that best system. Exceptions to those laws are likely: no matter how we categorise and correlate entities of higher level sciences, those entities do not exhibit strict uniformity (think of albino tigers and ravens, birds without wings, etc).

Deviating from the main topics of my enquiry I have, in the chapter on emergent laws, also focused on the infamous *ceteris paribus* clauses as they are usually discussed in the literature. I have propose an interpretation for these troublesome proviso clauses.

As for fundamental laws, there are also sophisticated reinterpretations or reformulations possible for grounded and emergent laws which let those laws appear strict even if, from a metaphysical perspective, they face instances that do not conform to the respective regularity. As an example for such an interpretative twist consider 'All Fs are Gs, *ceteris paribus*': by itself this is a strict, exceptionless statement, although it is supposed to codify a law with exceptions.

I have discussed the possibility of such linguistic strictifications for all four types of laws but I have also always tried to defend a metaphysical point of view. Consequently, I dare to conclude that I have indeed found metaphysically tenable concepts of '*ceteris paribus*' laws.

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