

Acronyme / Acronym	Metascience		
Titre du projet	Métaphysique de la science : niveaux, individus et dispositions à l'aune de la science actuelle		
Proposal title	Metaphysics of science : levels, individuals, dispositions in the light of present day science		
Comité d'évaluation/Evaluation Committee			
Type de recherche / Type of research	<input checked="" type="checkbox"/> Recherche Fondamentale / Basic Research <input type="checkbox"/> Recherche Industrielle / Industrial Research <input type="checkbox"/> Développement Expérimental / Experimental Development		
Coopération internationale (si applicable) / International cooperation (if applicable)	<input type="checkbox"/> OUI <input checked="" type="checkbox"/> NON		
Aide totale demandée / Grant requested	244 588 €	Durée du projet / Projet duration	36 mois

1. RÉSUMÉ DE LA PROPOSITION DE PROJET / EXECUTIVE SUMMARY	2
2. CONTEXTE, POSITIONNEMENT ET OBJECTIFS DE LA PROPOSITION / CONTEXT, POSITION AND OBJECTIVES OF THE PROPOSAL	3
2.1. Contexte et enjeux économiques et sociétaux / Context, social and economic issues	3
2.2. Positionnement du projet / Position of the project	4
2.3. État de l'art / State of the art	4
2.4. Objectifs et caractère ambitieux/novateur du projet / Objectives, originality and novelty of the project	7
3. PROGRAMME SCIENTIFIQUE ET TECHNIQUE, ORGANISATION DU PROJET / SCIENTIFIC AND TECHNICAL PROGRAMME, PROJECT ORGANISATION	10
3.1. Programme scientifique et structuration du projet / Scientific programme, project structure	10
3.2. Description des travaux par tâche / Description by task	10
3.2.1 Tâche 1 / Task 1	10
3.2.2 Tâche 2 / Task 2	11
3.2.3 Tâche 3 / Task 3	11
3.3. Calendrier des tâches, livrables et jalons / Tasks schedule, deliverables and milestones	12
4. STRATÉGIE DE VALORISATION, DE PROTECTION ET D'EXPLOITATION DES RÉSULTATS / DISSEMINATION AND EXPLOITATION OF RESULTS. INTELLECTUAL PROPERTY	15
5. DESCRIPTION DU PARTENARIAT / CONSORTIUM DESCRIPTION	15
5.1. Description, adéquation et complémentarité des partenaires / Partners description & relevance, complementarity	15
5.2. Qualification du coordinateur du projet / Qualification of the project coordinator	16

5.3. Qualification, rôle et implication des participants / Qualification and contribution of each partner	16
6. JUSTIFICATION SCIENTIFIQUE DES MOYENS DEMANDÉS / SCIENTIFIC JUSTIFICATION OF REQUESTED RESSOURCES	18
6.1. Partenaire 1 / Partner 1 : TOTAL REQUESTED FUNDS : €244 588.....	18
7. RÉFÉRENCES BIBLIOGRAPHIQUES / REFERENCES	19

1. RÉSUMÉ DE LA PROPOSITION DE PROJET / EXECUTIVE SUMMARY

At the beginning of the 20th century, an important group of philosophers of science united under the banner of logical positivism rejected metaphysics on the basis that it was senseless talk. This judgment carried on in later empiricist philosophy of science that dominated most of the first half of the century. Metaphysical questions, which include questions about the very notions used by science (like causality, reduction or reality), were thought best to be avoided. But criticisms coming from inside the empiricist tradition as well as from outside caused the decline and ultimately the fall of the logical empiricist philosophy of science.

Today's philosophy of science is both more naturalistic and more open to metaphysical questions. This new attitude has recently given rise to the blossoming field called "metaphysics of science", which asserts the necessity of articulating metaphysics and science. But where recent metaphysics of science has been more interested in general and abstract questions (like reduction in science in general, or causality in general), our project aims to examine the ontology presupposed by particular scientific discourse and practice. Our main goal is to make explicit the metaphysics of real scientific disciplines, mainly by finding what these disciplines are committed to from an ontological point of view. In other words, we intend to reconstruct the "scientific image of the world" offered by experimental sciences (Sellars 1963; van Fraassen 1980), that is, their description of what the world is made of (particles, fields, genes, neurons, etc.) To mark the difference with "metaphysics of science" as it has been developed in the last twenty years or so, we will use the term "metascience" to refer to the bottom-up approach we intend to adopt here.

Metascience distinguishes itself from most of other metaphysical projects by a number of significant features:

(1) rather than resorting to a priori conceptual analysis, Metascience looks at what real sciences posit as metaphysical entities or metaphysical relations. We are not against conceptual analysis, but we will apply it to concepts actually used in particular sciences, and not to abstract common concepts or common sense concepts. It should be noted that metascience does not renounce to the ambition of traditional metaphysics, as its aim is to produce general ontological claims; however, metascience's approach is bottom-up and *not* top-down;

(2) Metascience makes no philosophical presupposition about what is to be found. Observing real sciences in action might reveal a complexity that has been masked by a priori philosophical presuppositions. For instance, observation of real theoretical relationships between disciplines like cognitive neurosciences has led some to reject the traditional picture of intertheoretic reduction imposed by philosophers on science, and to adopt instead a characterization that respects the diversity of practices. In light of these observations, Grantham (2004) proposed to build a typology of intertheoretic relations that would conform to this diversity and capture more modest forms of unification of theoretical fields that are actually sought by scientists;

(3) Metascience is comparative in spirit. Where most metaphysical projects focus on one scientific discipline (most often physics), we will look at different scientific disciplines (namely physics, biology, psychology) and we will aim to find out whether certain conclusions about one field can be generalized to other fields, or whether certain stances or attitudes come into conflict (and, if so, how conflicts are or aren't resolved).

(4) Metascience focuses on areas of "overlap", where several sciences are studying what appear to be the same objects. One area in which this happens is cognitive neuroscience: the analysis of the mechanism underlying long-term memory requires at least four levels: i) the cognitive (or psychological) level at which the process of learning is explained, ii) the level of brain

structures such as the hippocampus which are modified during learning, iii) the mechanism of long-term potentiation (LTP) by which the synapses in these brain structures are modified, and iv) the molecular level at which LTP is explained in terms of the expression of genes and the change of conformation of receptor molecules in synaptic membranes. Such areas of overlap are a good place to look for disagreement about ontological commitments. Eliminativists such as Bickle (2003) argue, e.g., that the discovery of biochemical mechanisms underlying a psychological phenomenon such as learning makes psychological concepts superfluous, whereas Craver (2007) holds that such an analysis necessarily requires entities at several levels. When different sciences offer distinct (and sometimes conflicting) ontological descriptions of objects even though these objects seem to be the “same”, we believe that metascience will help to disentangle these complex situations;

(5) Metascience does not limit itself to one kind of entities (genes, for instance) or relationships (reduction), but looks at many different kinds of entities and relationships. In doing so, our hope is that certain important but underappreciated patterns might emerge;

(6) though our main focus will be the “scientific image” generated by different sciences, we will also be interested in the relationships between that image and what could be called the “manifest” or the “common sense” image of the world. Science is rooted in the manifest image, but often, it diverges from it. When confronted with such a divergence, which image should one choose? We will study different ways to solve this problem.

Metascience is structured around three axes, corresponding to concepts that some of us have already identified as important in their previous work on several particular scientific domains: 1) *levels of reality*, 2) *objects or individuals*, and 3) *dispositions*. We will study how these particular notions are used in different sciences. We take it to be promising to check in each case whether the same concept is used in different sciences and, if this is the case, to draw from this result conclusions on the structure of our conceptual system, on the makeup of reality according to its scientific representation, and on the possible conflict between the scientific and the commonsense worldview.

2. CONTEXTE, POSITIONNEMENT ET OBJECTIFS DE LA PROPOSITION / CONTEXT, POSITION AND OBJECTIVES OF THE PROPOSAL

2.1. CONTEXTE ET ENJEUX ÉCONOMIQUES ET SOCIÉTAUX / CONTEXT, SOCIAL AND ECONOMIC ISSUES

Jerry Fodor, in his characteristic ironic style, described the state of actual sciences as “an accelerating proliferation of new disciplines: the damned things multiply faster than college deans can keep up with them” (Fodor 1998). The dramatic multiplication of new disciplines or subdisciplines potentially means new kinds of entities, new ways of creating relationships between diverse disciplines or domains, and an increase in the complexity of the scientific image, that is, the image of the world that can be elaborated on the basis of current sciences. These new disciplines are creating knowledge about the entities that are part of the world in which we live, and this new knowledge can clash with what ordinary people have always believed or are disposed to believe. Therefore, we urge the necessity of the development of a truly unifying philosophical project, the foremost objective of which will be to confront the ontologies currently offered by different experimental sciences, and to confront these ontologies with the ontology of everyday life. Since metaphysical research investigates and develops transverse concepts, like that of the individual or that of causality, our project is intrinsically a metaphysical enterprise, aiming at confronting and unifying important aspects of today’s sciences that make use of such metaphysical concepts. If sciences provide answers about what such or such aspect of the world is like, the domain of metascience uses this knowledge to provide a global worldview. Our conviction is that this work, which consists in the unification of different sciences and in the construction of a coherent, comprehensive ontology, is fundamentally philosophical in nature, and can only be accomplished by philosophers with a strong involvement in the understanding of current sciences.

2.2. POSITIONNEMENT DU PROJET / POSITION OF THE PROJECT

This project falls within the scope of the “metaphysics of science”, a domain that has attracted many researchers and projects worldwide in the last five years or so. Metaphysics of science is certainly one of the hottest topics in today’s philosophy of science. We describe here the main characteristics of these projects, while below we explain in detail what makes our project original with regard to them.

It is possible to distinguish at least two trends among recent projects in metaphysics of science. The first trend corresponds to several research groups that have worked in the field of metaphysics of science in general. To this first trend belong the British (AHRC) project “*Metaphysics of Science*” (<http://www.bristol.ac.uk/metaphysicsofscience/>), now terminated, which was run by the universities of Bristol, Nottingham and Birmingham (Max Kistler has been speaker at three conferences of this project and has co-organised one of its workshops, in Grenoble, in December 2008), and the German (DFG) project “*Causation, Laws, Dispositions, Explanation: at the Intersection of Science and Metaphysics*” (Budget: 1 500 000 €. http://www.clde.uni-koeln.de/?page_id=934), run by the university of Cologne, which has started in 2010.

The second trend corresponds to more focused projects, bearing either on a particular concept or on a specific science. Representative of this second trend are the British (AHRC) project “*Phenomenal Properties*” run by the university of Hertfordshire, which studies how cognitive science helps improving our understanding of conscious experience, and the Norwegian project “*Causality in Science*” (Budget: 1 245 000 €. <http://www.umb.no/causci/article/about-causci>), run by the Norwegian University of Life Sciences (UMB), which has started in 2011 and focuses on the concept of causation, and more particularly on its role in biology (Max Kistler is associate member of these last two projects). An international Society for Metaphysics of Science has recently been founded (<https://sites.google.com/site/socmetsci/>). Other important European metaphysics of science research groups are located in Switzerland (Lausanne, M. Esfeld <http://www.unil.ch/philo/page43600.html>) and Italy (Rome, M. Dorato <http://host.uniroma3.it/dipartimenti/filosofia/personale/doratoweb.htm>). They would be privileged interlocutors and partners for our project.

Several French research projects, though bearing on themes that belong to the metaphysics of science, have a narrower focus, concentrating either on one science or on one concept. To the first category belong the ANR projects “*Compuphys*” (“The computational turn in physics”, ended 31 december 2011) directed by Anouk Barberousse, and “*Eco-evo*” (“Evolutionary Biology and economic theory: historical perspectives of a two-way relationship”, ends 30 september 2012) directed by Jean Gayon, collaborator of the present project. The latter project studies the interaction between two sciences, economy and evolutionary biology, but not within a metaphysical perspective.

To the second category belong the French-German (ANR-DFG) project “*Causaproba*” (“Causality and probability” (ends 30 July 2012), directed by J. Dubucs and W. Spohn, which analyses probabilistic theories of causation, and in particular formal models of causal reasoning, which are used in sciences studying complex systems, such as economy, epidemiology, or agronomy (M. Kistler is member of this project), as well as the project (Partenariat Hubert Curien Orquid) “*Scientific individuation: what counts as an individual in the physical and the living world?*”, directed by Alexandre Guay (member of this project) and Ruey-Lin Chen (National Chung Cheng University, Taiwan).

This wealth of research programs naturally constitutes a highly favorable context for our Metascience project. At the same time, it makes all the more essential, we believe, the original approach to metaphysics of science presented here.

2.3. ÉTAT DE L'ART / STATE OF THE ART

A research project in the philosophy of science with metaphysical ambitions may come as a surprise, to the point of seeming paradoxical. Indeed, at the beginning of the 20th century, philosophy of science defined itself mainly in opposition to metaphysics (Mach 1883; Duhem 1906;

Carnap 1931), which was taken to be a field lacking rigorous methods, thus letting it be hostage to arbitrariness and dogmatism (Hahn, Neurath, Carnap 1929) Logical empiricism, first promoted in Vienna and Berlin in the 1920s and the beginning of the 1930s, recommended abandoning metaphysical theories with their shaky epistemic status and suggested a new start based on the hypothesis of the *unity of science* (Hahn, Neurath, Carnap 1929). According to logical empiricism, scientific knowledge is better justified than metaphysics because it rests on a solid foundation: the pillars of observation and logic. Metaphysical statements, which cannot be justified by observation or logic, were taken to be strictly speaking meaningless. Given this conception of metaphysics and of science that has been dominant in the 20th century, at least in the Anglo-Saxon world, how can we explain that it could be legitimate to raise questions about the structure of reality revealed by the sciences in metaphysical terms? How can one pretend to reconcile science and metaphysics?

According to logical empiricism as it was developed by the philosophers of the Vienna circle, the question of the unity of science had two aspects: 1) The methodological unity of science rested on the experimental method and on a universal model of explanation; 2) The theoretical unity of science corresponded to the idea that the contents of scientific knowledge had to be structured in such a way that they constitute, at least in principle, a unique body. According to the doctrine of logical empiricism, metaphysical questions that arise about the objects of scientific research can only be addressed in a rational and coherent way once they have been translated into questions bearing on scientific theories, construed as sets of propositions. To the question of what is meant by the statement that a physical or biological event causes another event, logical empiricism substituted the analysis of the logical form of causal explanations provided by the sciences (Hempel and Oppenheim 1948). To the question: "what is a dispositional property?" (such as elasticity or electrical conductivity in physics, reactivity in chemistry, or fitness in biology), it substitutes the analysis of the logical form of disposition statements (Carnap 1936/7). In this conception, there is no room for metaphysical questions as such; at best, metaphysics is seen at best as a conceptual framework that makes scientific research possible but has itself the status of a convention.

However, during the second half of the 20th century it turned out that the distinctions that helped to justify the neat separation between science and metaphysics, that is, between the empirical content and the conventional form of scientific propositions, were themselves ill grounded. There is no difference in principle but only in degree between analytic and synthetic statements (Quine 1953b); furthermore, it has become very controversial whether there is a principled distinction between observational and theoretical statements, which might ground a metaphysical distinction between "observable" and "theoretical" entities (Maxwell 1962, Kuhn 1962, Hacking 1983).

This evolution explains why it has become legitimate again to interpret the issue of the unity of nature in a metaphysical way. It now appears artificial to separate the analysis of the general conceptual tools that are used throughout the sciences, such as cause, law, individual object, process, mechanism, reduction, from the metaphysical analysis of the structure of reality as represented by science (Dupré 1993).

We take as the starting point to this "return to metaphysics" the conception of ontology developed by Quine (1953a): the ontology of a given (scientific or popular) theory consists of the objects to which the theory is "ontologically committed", that is, those objects that exist if the theory is correct. Technically, Quine's proposal is to take quantification as a criterion of ontological commitment. His hypothesis is that a theory is committed to the existence of a set of objects if and only if they belong to the domain in which the bound variables appearing in the axioms and theorems of the theory take their values. More simply, the idea is to look at the universal ("every object x is such that...") and existential ("there is an object x such that...") generalizations that are part of the theory. What exists according to the theory is the set of objects in which the variables x take their values. Quine's position is a good start but it is clearly insufficient. It cannot be adequately used when many formal versions of the same theory exist (e.g., in classical mechanics) or when the theory is apparently not unified (e.g., in fluid mechanics) or when many interpretations of the theory are sustainable (e.g., in quantum mechanics).

One of the leading ideas we would like to defend in our project is that the domains that lie at the intersection of several sciences hold particular promise of shedding light on the structure of

reality. Indeed, the necessity of articulating different approaches diminishes the influence of conventional factors that inevitably accompany the construction of theories. Our project of studying the articulation of different sciences has its roots in a tradition of research on the relations between theories. Traditionally, the concept of *reduction* has provided the framework for philosophical analyses of the process of integration of different theories. According to reductionism, when a reduction has been achieved, phenomena that had been objects of different sciences appear to be unified in a unique domain. One of the paradigms of accomplished reductions between scientific theories is the discovery of the articulation of the macroscopic phenomena studied by thermodynamics with the microscopic objects of statistical mechanics. By virtue of that reduction (the details of which continue to be a matter of debate: Sklar 1993), the domain of all those phenomena is now unified. Another case that is increasingly considered as paradigmatic, though much more complex and much farther away from being fully accomplished, is the reduction of certain cognitive phenomena to neurophysiology: e.g., certain forms of memorization are often claimed to be on their way of being reduced to processes of modification of neurons and synaptic structures (Bickle 1998; Bickle 2003).

According to logical empiricism, the reductive integration of two theories takes the form of a deductive-nomological explanation; in other words, reductions are deductive arguments whose premises contain the axioms (and theorems) of the reducing, more fundamental, theory and whose conclusion is the conjunction of the axioms of the reduced theory. According to this model, a reduction shows that the less fundamental theory is a logical consequence of the more fundamental theory (Nagel 1961).

Since the 1960s, several authors have argued that most classical cases of reductions that can be found in the history of science, such as the integration of Kepler's laws of planetary motion within Newtonian mechanics, do not have the deductive form of Nagel's model (Popper 1957, Feyerabend 1962, Kuhn 1962). According to these critics of Nagel's account, history shows that reductions are only scientifically fruitful insofar as the new (reductive) theory improves and corrects the old (reduced) theory. They go on to note that this is incompatible with the idea that the reduced theory be logically deducible from the reducing theory. However, it has turned out to be possible to take into account the fact that reductions are in general not conservative but corrective, without abandoning the general framework that takes the core of a reduction to be a deductive argument (Schaffner 1993).

The difficulties encountered by the classical model of reduction, and above all the difficulty of taking account of the corrections that make reductions fruitful, have led to the elaboration of alternative models of reduction. In the framework of the semantic account of theories, which takes them to be sets of models rather than sets of propositions (van Fraassen 1980, Giere 1988), reduction has been analyzed in terms of relations among models: a reduction consists in demonstrating that all models of the reduced theory are also models of the reducing theory (Bickle 1998; Moulines 2006).

Other authors have suggested that only in exceptional cases does the integration of theories take the form of the absorption of one theory into another. They argue that it takes more commonly the form of the fusion of the domains into a single domain. According to them, typical relationships between theories of different levels in disciplines like cognitive neuroscience does not lead to such an absorption (e.g., of psychology to neuroscience). Instead, the old theories, while they get modified by their integration or melting together, remain indispensable parts of the new "interfield theory" (Darden et Maull 1977; McCauley 1996). Another important suggestion is that "interconnections among theories" (Grantham 2004) can take various forms, one of which is reduction, but many others being non-reductive.

The notion of mechanism plays a key role in contemporary debates on the analysis of the integration of several theories into a unified field (e.g., Craver 2007, following Machamer, Darden and Craver 2000). A mechanistic analysis, which is a major form of explanation in biology and neuroscience, shows how the parts of a complex system are articulated with each other in such a way as to make possible that the whole mechanism accomplishes its function. The relevant functional parts of such systems are in general not studied by the same science that studies the system as a whole; this makes the contribution of several sciences indispensable to the explanation of how the whole mechanism accomplishes its function. The explanation of the functioning of an

organ of a living system calls, e.g., for theories studying objects at different levels within the hierarchy of composition, such as the physiological, cellular and molecular levels. The same is true for the mechanistic analysis of psychological processes, such as the fixation of long-term memory. It is only possible to explain how a rat learns to orient itself in a labyrinth if the changes corresponding to learning at the level of the behavioral dispositions of the animal as a whole are shown to arise from modifications at the level of the hippocampus of the animal, whose neurons undergo a transformation called “long term potentiation” (LTP), which in turn arise from modification of the synapses of those neurons and of the receptor molecules situated at those synapses, and finally at the genetic level, to the extent that the modification of synaptic structure depends on the expression of certain genes (Craver and Darden 2001, Craver 2002).

In contemporary debates on metaphysical concepts used and presupposed in science, such as the concepts of cause, law, individual, and disposition, it is widely accepted that empirical science provides the ultimate criterion for the existence of objects of a certain sort. However, there is a controversy about how to extract such ontological information from the analysis of scientific theories and practices. Even though Quine’s proposal remains the most influential, it has recently been argued (Armstrong 2004) that the ontological commitment of a theory is not limited to the objects in the domain of the bound variables of the theory, but extends to the properties expressed by the predicates used in theoretical statements. According to the so-called truthmaker hypothesis, a theory is ontologically committed to the properties expressed by the predicates it uses, even if these predicates are not the object of higher-order generalizations. The analysis of precise scientific theories will enable us to take sides in this debate.

Another aspect of the debate on ontological commitment that goes beyond the framework introduced by Quine concerns the articulation of the ontology implicit in scientific theories with the ontology presupposed by the conceptual framework of common sense. This has been the focus of a recent debate on the analysis of reduction. According to an influential hypothesis (Kim 1998, Jackson 1998, Chalmers 1996), common sense concepts and scientific knowledge can give rise to a unified conception of reality in the following way: in a first step of a priori conceptual analysis, relying only on common sense, the concept of a type of object is “functionalized”, which means that the analysis of the concept shows it to have a functional content. The concept of water is, e.g., taken to be the concept of a substance characterized by its functional role. What is essential to the common sense concept of water is not what it is (its microscopic composition) but what it does. The identity of water is determined by the causal interactions of that substance, and in particular by what water can do or enable us to do in various circumstances. Empirical science steps in at the second stage, which consists of the discovery of the intrinsic nature – and in particular the microscopic constitution – of the objects that play the functional role analyzed at the first stage. In a third and last step, which achieves the integration of scientific knowledge into the framework of common sense, science develops a detailed explanation of why and how the objects described in the second step fit to all aspects of the functional role uncovered in the first step. This model of so-called “functional reduction” has the ambition to complete the traditional conception of reduction as the means by which the sciences tend progressively towards their unification. However, the framework of functional reduction has also been used to argue for the thesis that there are domains of phenomena the scientific knowledge of which must inevitably remain incomplete. In the philosophy of cognitive science, some philosophers who accept the criterion of the ontological commitment of scientific theories have been led to the conclusion that scientific knowledge of perceptual experience cannot possibly be completed (Jackson 1992; Chalmers 1996; Kim 2005). The thesis of the inaccessibility of the phenomena of subjective perceptual appearance to scientific knowledge is clearly dependent on the framework of functional reduction, so that its evaluation is inseparable of the evaluation of the universal scope of the framework itself.

2.4. OBJECTIFS ET CARACTÈRE AMBITIEUX/NOVATEUR DU PROJET / OBJECTIVES, ORIGINALITY AND NOVELTY OF THE PROJECT

The aim of the Metascience project is to make a significant contribution to the metaphysics of science, through a direct confrontation with today’s sciences, and more precisely on the basis of the detailed analysis of specific cases of scientific research in physics, biology and psychology.

Most research presently done in the metaphysics of science, understood as the field of research whose objective is the analysis of the fundamental concepts structuring scientific research, such as the notions of *individual*, *cause*, or *disposition*, proceeds by pure conceptual analysis. This strategy of philosophical research is sometimes explicitly stated and defended. It corresponds to what Strawson (1959) has called a “*descriptive metaphysics*”, which aims at making explicit the conceptual structure underlying common sense. The method appropriate for this aim is the conceptual analysis of ordinary language statements and the intuitions they express. This approach structures a large part of the research on causation. Most of the debates on the various attempts to analyze the concept of causation are structured by the search for so-called “counter-examples”: philosophical accounts of causation are evaluated by comparing the judgment they yield in various situations to the intuitive judgment on that situation. If the theory yields a result that contradicts naive intuition, the intuitive judgment is considered to be a counter-example to the theory. Such a counter-example is taken to refute the theory, at least *prima facie*, until appropriate modifications have been found that bring the theory in line with naive intuition. To the extent that common sense ignores scientific knowledge, science is irrelevant to the task of descriptive metaphysics. Within the framework of descriptive metaphysics, the analysis of a concept such as causation is intended to cover the application of that concept to situations that are incompatible with the laws of nature (in other words nomologically impossible) such as magical actions at a distance, telepathy or time travel. Our common sense concepts are indeed flexible enough to allow us to conceive of such situations, as shown by the ease with which we understand fairy tales and science fiction novels.

This project develops a completely different type of metaphysical enquiry. Our main interest does not lie in the analysis of the conceptual structure underlying common sense. Rather, our aim is to uncover the conceptual structure that underlies scientific theories and practices. To the extent that science often goes against common sense, to choose as our main criterion of adequacy agreement with science, not common sense, makes our approach belong to Strawson’s category of “*revisionist metaphysics*”. Hence, if, for example, the concept of individual at work in biology includes within an individual organism all the organisms that live in symbiosis with it (Pradeu 2012a) whereas common sense excludes them, we will ignore the latter and take seriously the former. More generally, our project aims at analyzing scientific concepts *at work in science* (even if they come into conflict with commonsense ontology).

This research strategy is sometimes announced but rarely followed. Even J. Ladyman and D. Ross, who present their recent and influential book *Every Thing Must Go: Metaphysics Naturalized* (2007) as a manifesto for a new kind of metaphysics that analyses science rather than common sense, hardly practice it themselves¹. In a contrasting way, Tim Maudlin (2007), in a book that displays more modest ambitions, managed to really propose a new metaphysical view of objects and properties based on sophisticated mathematical representations, namely principal fibre bundle, used in fundamental physics.

However, what is most distinctive of our approach is the strategy of analyzing various metaphysical key concepts by evaluating their role in structuring and accounting for scientific activities in *more than one discipline*. With some rare exceptions (one is Cartwright 2007 who analyzes the role that causation plays in both physics and economy), almost all research in the metaphysics of science takes only one science into consideration, which is mostly physics. In contrast, we believe that comparing the roles that a concept plays in different sciences may reveal its fundamental structure and features more reliably than an analysis that remains limited to a single discipline. The three key concepts that we will analyze in depth are *levels of reality*, *individuals*, and *dispositions*. The reason for this choice is straightforward: we are convinced that they are among the most founding concepts for today’s metaphysics of science. Undoubtedly, *levels of reality* and *dispositions* have been the most widely discussed notions in metaphysics of science as it has been conducted in the last ten years (e.g. Ellis 2001, Kistler ed. 2006, Bird 2007, Kistler and Gnassounou eds. 2007, Bedau and Humphreys 2008, Suarez ed. 2010). The situation is

¹ One of the rare analyses of a scientific theory appearing in this work bears on so-called entangled systems in quantum mechanics. Ladyman and Ross conclude from their analysis of the relevant theory that atomism is inadequate, because it doesn’t fit with quantum mechanics. The ultimate constituents of reality cannot be conceived as localized in space.

slightly different with the notion of an *individual*: while it has been one of the most fundamental notions in general metaphysics from Aristotle to Strawson and beyond, it has not constituted a major focus of general metaphysics of science as such; instead, it has given rise to a wealth of more specialized studies, in philosophy of physics (e.g., Castellani 1998, French and Krause 2006; Morganti 2009, Brading and Castellani 2003), philosophy of biology (e.g., Buss 1987; Maynard-Smith and Szathmary 1995; Michod 1999; Wilson 1999; Wilson 2004; Godfrey-Smith 2009), as well as in philosophy of cognitive sciences (e.g., Wilson 2004). We think that the time is ripe to confront these different specialized approaches and unify them into a cohesive reflection on the notion of individuality in experimental science.

Thus, against the “provincialization” of scientific and philosophical disciplines, our analyses will be situated at an important level of generality. If it turns out, e.g., that the obstacles against the reduction of thermodynamics to statistical physics are analogous or similar to the obstacles against the reduction of classical conditioning to neurophysiology, this observation might suggest and justify conjectures about micro-reduction in general. If it turns out that they are not analogous or similar, it might suggest and justify conjectures concerning the different forms that relationships between theories take. Other sources of possible general conjectures would be the observation that the definition of what counts as an individual raises similar problems in physics and in biology or the role of dispositions in different domains like physics and psychology.

Diagram 1 sums up the objectives of our project.

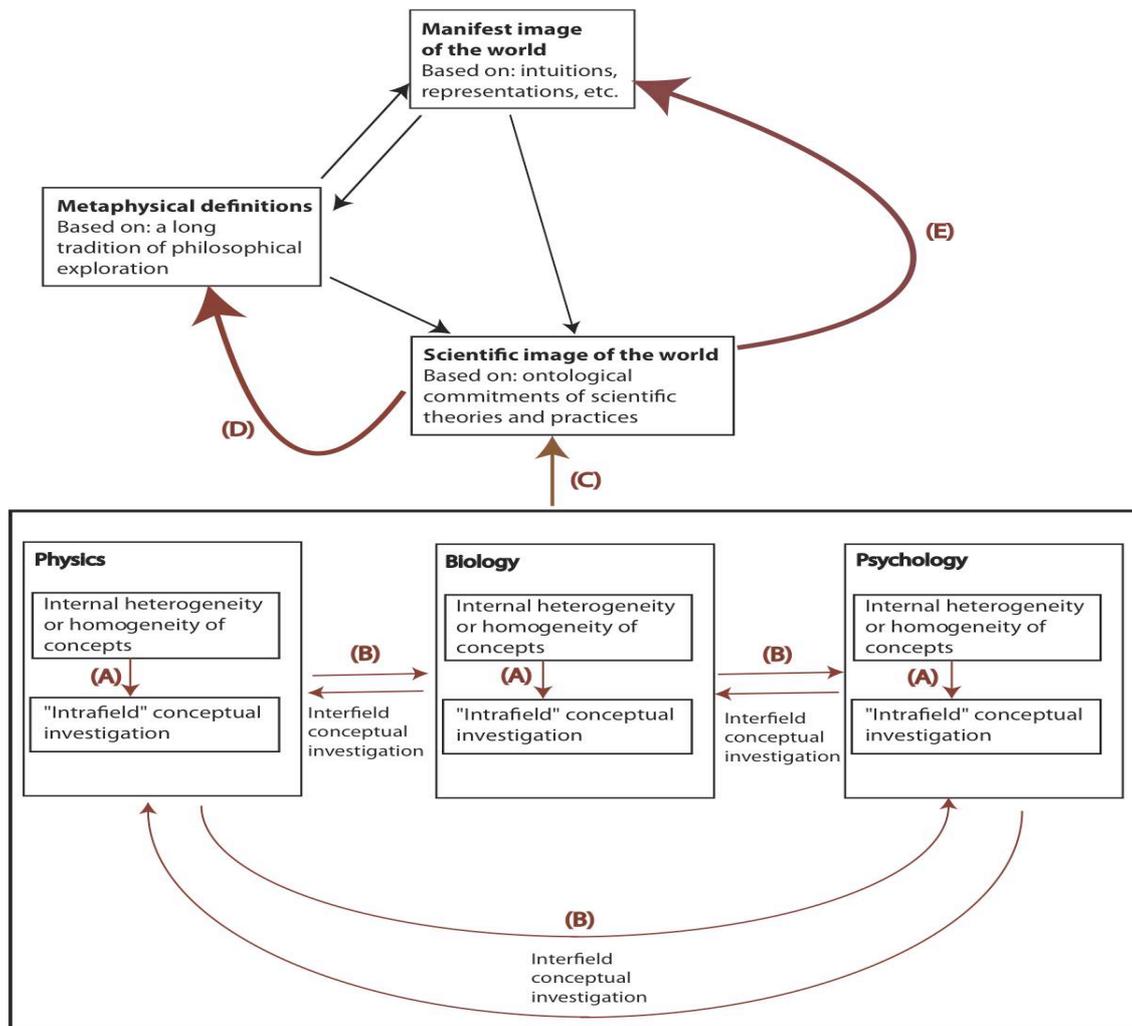


Diagram 1: Conceptual explorations within the “Metascience” project

This diagram first shows the different approaches of interest to apprehend our world: the “manifest” or “everyday” image of the world, the metaphysical approach, the scientific image of the world, and their interactions (for example, the intuitive concept of what an individual is frames in part the metaphysical concept of the individual, but a subsequent elaboration of the metaphysical concept can lead to a reevaluation of the intuitive concept). Second, the diagram shows how the scientific image of the world can be elucidated through philosophical work. Within each specific science (physics, biology, psychology), a given concept (e.g., the concept of individual) can have different meanings and lead to different ontologies in different subdomains (e.g., an evolutionary individual, a physiological individual, and an ecological individual within biology) (“internal heterogeneity”). Our first aim (*task A*) will be to investigate these “intrafield” differences and tensions, and, if possible, to work them out. But different sciences can also have, and indeed often have, different definitions of a given concept (e.g., the concept of what it means to be an individual particle in physics and the concept of a biological individual: different criteria of individuation are used in each case). Our second aim (*task B*) will be to investigate these “interfield” differences and tensions, and, if possible, to work them out. Accordingly, interfield comparisons make possible to shed light on structural features that are common to different sciences (e.g., a common method for articulating different levels of reality). Thanks to this comparative method applied here to three major scientific fields (physics, biology, psychology), our third aim (*task C*) will be to elaborate the scientific image of the world, which is not a simple reflection of the objects that scientists posit, but instead the result of a complex philosophical work of confrontation and unification of transverse concepts in different sciences. Though these tasks A, B and C will be our main focus, we will also show how this philosophically informed scientific image of the world may or may not modify key metaphysical concepts (e.g., individual, level of reality, etc.) (*task D*), as well as the everyday image of the world (e.g., the everyday concept of an individual) (*task E*). Thus, through a detailed analysis of three different experimental sciences and a thorough examination of their convergences, our aim is to offer a new, scientifically informed, metaphysics, one which can subsequently dialogue with more traditional metaphysical conceptions.

3. PROGRAMME SCIENTIFIQUE ET TECHNIQUE, ORGANISATION DU PROJET / SCIENTIFIC AND TECHNICAL PROGRAMME, PROJECT ORGANISATION

3.1. PROGRAMME SCIENTIFIQUE ET STRUCTURATION DU PROJET / SCIENTIFIC PROGRAMME, PROJECT STRUCTURE

3.2. DESCRIPTION DES TRAVAUX PAR TÂCHE / DESCRIPTION BY TASK

3.2.1 TÂCHE 1 / TASK 1

Axis 1. Levels of reality. Responsible: Gayon; Other collaborators: Guay, Huneman. Kistler, Pradeu.

- 1.1. **Compositionality, states and macrostates.** Investigate different ways of articulating levels in physics and biology.
- 1.2. **Emergence within and across sciences.** Assess concepts of emergence (compositional, computational, singularity-based) and their relative validity within specific sciences as well as their interest for making sense of relationships across sciences.
- 1.3. **The natures of realization and the special sciences.** Investigating the concepts of realisation, their relationships to causation and explanation, and their role in the scientific picture of the world.

3.2.2 TÂCHE 2 / TASK 2

Axis 2: Individual objects in physics and biology. Responsible: Guay, Pradeu. Other collaborators: Gayon, Kistler, Ruphy.

2.1. Interface with field scientists

2.1.1. Interface with physicists to determine the conception they have of the notions of "object" and "individual": Guay, Ruphy.

2.1.2. Interface with biologists to determine the conception they have of the notions of "object" and "individual": in evolutionary biology (Gayon, Pradeu), in ecology (Gayon, Huneman, Pradeu), and in physiology, especially immunology and developmental biology (Pradeu).

2.2. Philosophical elaboration of scientifically informed concepts of "object" and "individual"

The usages of the very notion of "object" and "individual" offered by scientists cannot be taken at face value. They need to be integrated, and hence probably modified, reframed, selected, in order to obtain a general, coherent worldview. This work needs to be based on the interactions with scientists developed in sub-axis 2.1, but it can be elaborated only by a team of philosophers and historians of science. Hence the following objectives:

2.2.1. Philosophical construction of a scientific image of the world based on physics: Guay, Kistler, Ruphy.

2.2.2. Philosophical construction of a scientific image of the world based on biology: Gayon, Huneman, Pradeu.

2.2.3. Philosophical construction of a scientific image of the world based on psychology: Guay, Kistler, Ludwig.

2.3. Elaboration of a unified, as coherent as possible, scientific image

This will be the ultimate step of axis 2, aiming at a synthesis. The most important aspect of axis 2, and obviously the one that has been almost completely neglected by philosophers so far, is the determination of convergences, overlaps and conflicts between the different metaphysical perspectives elaborated on the basis of different experimental sciences. This is where we hope to be the most innovative, because our team is truly interdisciplinary, with an expertise in different scientific fields.

People involved, under the supervision of Guay and Pradeu: Gayon, Huneman, Kistler, and Ruphy, as well as some scientists (Evelyn Houlston, Minus van Baalen, Richard Michod in biology; Carlo Rovelli in physics).

3.2.3 TÂCHE 3 / TASK 3

Axis 3: Dispositions in physics and psychology. Responsible: Kistler; other collaborators: Guay, Ludwig.

3.1 Objective: Analyze the ontology of perception in the light of the dispositional description of both perceivable sensory qualities (such as colors) and perceptual capacities, such as capacities of discrimination. Situate so-called "qualia" of perception with respect to psychological space of representation (subjective) and discriminable aspects of perceivable sensory qualities (objective).

3.2. Objective: Compare dispositional notions in psychology and physics. Does the difficulty of analyzing dispositions in terms of categorical states and observable manifestations have the same reasons in both sciences? Examples: iconic memory in cognitive psychology and specific heats in physics.

3.3. CALENDRIER DES TÂCHES, LIVRABLES ET JALONS / TASKS SCHEDULE, DELIVERABLES AND MILESTONES

Diagram 2. Structure of the project and the team

Axis 1. Levels of reality (Gayon)	Axis 2. Individuals and objects (Guay, Pradeu)	Axis 3. Dispositions (Kistler)	General tasks
1.1. Composition & states (Guay, Gayon, Huneman)	2.1. Work at the interface with field scientists (Gayon, Guay, Huneman, Pradeu, Ruphy)	3.1. Dispositions in perception (Kistler, Ludwig)	Conception of a website on the metaphysics of experimental sciences. (Postdoc)
1.2. Emergence (Huneman, Kistler, Ludwig)	2.2. Philosophical elaboration of scientifically informed concepts of "object" and "individual" (Gayon, Guay, Huneman, Kistler, Pradeu, Ruphy)	3.2. Dispositions in physics and psychology (Guay, Kistler, Ludwig)	Creation of a full list of references in metaphysics of science (Postdoc)
	2.3. Elaboration of a unified, as coherent as possible, scientific image (under the supervision of Guay and Pradeu)		

The subteams of the project will interact accordingly to the overall structure of the project represented in diagram 2.

1.3. Tasks schedule, deliverables and milestones

Year 1

Workshop organized by Pradeu and Guay:

“Toward a general concept of individual in natural sciences”

The main objective of this workshop is to propose and evaluate different unified conceptions of the individual that could apply as well to physics, biology and possibly other sciences. The current workshop will build on previous work, and especially on the already mentioned workshop “individuals Across Sciences: A Revisionary Metaphysics?” (May 18-20, 2012), focused on comparative studies.

Suggested invited speakers, in addition to project members:

- Gordon Belot (University of Michigan) philosopher
- Mathias Frisch (University of Maryland) philosopher
- Scott Gilbert (Swarthmore College) biologist
- Peter Godfrey-Smith (City University of New York) philosopher
- Richard E. Michod (University of Arizona) biologist
- Carlo Rovelli (University of the Mediterranean) physicist
- Erhard Scholz (University Wuppertal) historian of physics and mathematics
- Elliott Sober (University of Wisconsin) philosopher

Seminars

We take it as essential to construct this research project in constant interaction with teaching. Therefore, our intention is to give courses that will discuss some of the concepts and problems raised within our research project.

Pradeu will give a Master's seminar in the Master Lophisc at Paris-Sorbonne University on the construction of the biological individual. The question that will be the focus of the seminar is the following: What constitutes, in the living world, an "individual"? Even though we have the intuition that it is easy to distinguish living "individuals", understood as organisms, it is actually very difficult to know what counts as a biological individual. When colonial organisms, or hierarchies of entities (for example cells in a multicellular organism), are concerned, intuition can no longer be a proper guide, and it is therefore necessary to lean on biological concepts and theories. In this seminar, we will be interested in developmental biology, which accounts for the construction of a living thing through time, and we will try to show how an analysis of development makes it possible to answer precisely to the problem of determining what counts as an individual in the living world.

Huneman will organize a Master seminar called "Composition, causation and realization" at Pantheon-Sorbonne University. It is commonly claimed since Fodor (1977) that special sciences are characterized by the fact that they deal with multiply realizable properties. Realization as such involves a specific relation to both causation, and composition: some argue that realisers compose the entities having the realized properties; some claim that realization goes hand in hand with other mechanisms; some argue that the realization relation is a causal relation, etc. The seminar will read papers which investigate the notions of realization and multiple realizability, in order to assess to what extent these notions allow us to make sense of levels of reality.

Year two

Workshop organized by Gayon, Huneman and Kistler
"Levels of Reality: States, Macrostates and emergence".

This workshop aims at investigating the relevance of different conceptions of levels of reality, using either the distinction between microstate and macrostate, or the mechanistic conception of the analysis of complex systems, for several fields of physics, biology and neuroscience. Correlatively, it will confront mereological, combinatorial and computational views of emergence, and ask in each case whether this emergence has to be understood in an epistemological or ontological way.

Invited Speakers, in addition to project members:

- Carl Hoefer (Barcelona)
- Joseph Berkovitz (Toronto)
- Paul Humphreys (Virginia, Charlottesville)
- Robert Batterman (University of Pittsburgh)
- Joshua Epstein (Johns Hopkins University, Baltimore)
- Carl Gillett (Northern Illinois University)
- William Wimsatt (University of Chicago)
- Carl Craver (Washington University, St Louis)
- Michael Redhead (London School of Economics)
- Matt Haber (University of Utah)

Kistler will give a Master's seminar in the Master Lophisc of Paris 1 Pantheon-Sorbonne University, on the notions of power and disposition. The seminar will review the reasons for which it seems to be impossible to eliminate dispositional concepts from scientific and common sense discourse, by analyzing them in terms of triggering conditions and manifestations, even using logical tools stronger than classical logic, such as counterfactual conditionals. Another part of the seminar will be dedicated to the concept of a categorical base (or "causal base"), and to the question whether some or even all disposition concepts are ultimately reducible to such a basis, or whether there are ungrounded "basic" dispositions. Special attention will be given to so-called multi-track dispositions: such disposition concepts are particularly useful, both in science and in

common sense because they provide a unified grounding for many different manifestations in different circumstances.

Ludwig will give a Master's seminar in the Master Lophisc at Paris-Sorbonne University on the emergence of consciousness. The main questions addressed will be the following. Can the psychological concepts, in particular the concepts of perceptual and emotional states, be functionalized? To what extent can the neuroscientific and the psychological views of conscious experience be reconciled? Kim's causal exclusion argument will be discussed, as well as Chalmers influential argument to the effect that the neuroscientific conception of consciousness is doomed to remain incomplete.

Gayon will give a Master's seminar called "Intertheoretic relations in biology: scales, timescales and hierarchies" in the Master Lophisc. Life sciences are hierarchically ordered, according to biological hierarchy: for instance, molecular biology, cell physiology and physiology address different levels of the biological hierarchy, defined by specific timescale and spatial scales... Various conceptions have been proposed of the intertheoretic relations between biological sciences at different levels: reduction of genetics to molecular biology, "extrapolation" of microevolutionary theory to macroevolutionary, etc. The seminar will read papers which elaborate specific views of particular intertheoretic relations, and of what an intertheoretic relation in biology should be.

Year three

Workshop organized by Kistler, Guay and Ludwig:

"Dispositions in Physics and Cognitive science"

The workshop will be dedicated to the role of dispositional concepts in physics and the psychology of perception. The question is whether dispositional concepts differ from other theoretical concepts in requiring that the system to which they apply is incompletely known. Such a requirement of partial ignorance may be plausible for psychological dispositional concepts such as discriminability or "just noticeable difference" but seems to be incompatible with the claim (made by Harré, Thompson, Dorato and others) that the fundamental particles and fields postulated by physics are conceived in a dispositional way.

Invited speakers, in addition to project members:

- Ned Block (New York University)
- Diana Raffman (Toronto)
- Jérôme Sackur (ENS, Paris)
- Mauro Dorato (Rome 3)
- Marc Lange (University of North Carolina, Chapel Hill)
- Rom Harré (Georgetown University, Washington DC, USA)
- Ian J. Thompson (Lawrence Livermore National Laboratory, USA)

Final Conference

Organized by Kistler

"New trends in the metaphysics of science"

This final conference will be preceded by a short summer school (4 days) to prepare students and colleagues who work in neighboring fields, either in philosophy or in science, to the conference. We will apply for CNRS funding for this summer school.

This conference is conceived as having three goals (in addition, of course, to the goal of training students, which will have been fulfilled thanks to the summer school). The first one will be for the members of the Metascience group to present their final results. The second one will be to gather a group of specialists that will explore new perspectives in metaphysics of science. The third one will be prepare a handbook on the new metaphysics of science.

Invited speakers, in addition to project members:

- James Ladyman (Bristol)
- Michael Esfeld (Lausanne)
- Alexander Bird (Bristol)
- Tim Maudlin (New York University)
- John Earman (Pittsburgh)

4. STRATÉGIE DE VALORISATION, DE PROTECTION ET D'EXPLOITATION DES RÉSULTATS / DISSEMINATION AND EXPLOITATION OF RESULTS. INTELLECTUAL PROPERTY

The project aims at producing several research articles, edited volumes and monographs on each axis. Given our commitment to the relevance of metaphysics of science for sciences themselves, each team aims at producing a review paper in scientific journals such as *Nature* (News & Views), *Science*, or *Cell*, plus also specialized journals in physics, biology and psychology (*Physical Review X* (a new journal that will launch its first issue in autumn 2011), *TREE*, *Journal of Theoretical Biology*, or *Trends in Cognitive Science*).

In Axis 1, Gayon and Huneman will edit a set of papers about compositionality and emergence gathering results of the first workshops in axis 1 – possibly a special issue in *Erkenntnis* or *Synthese* – insisting on the comparisons between physics, biology and neuroscience. In addition, the last workshop will be the basis of a monograph, *Realization in Science: The Leveled Structure of Reality*, under the supervision of Gayon and Kistler.

In Axis 2, Guay and Pradeu will edit a volume on *Individuals in Biology and Physics*. Furthermore, a collective paper focused on the specificities of individuation in biology and physics will be submitted to a leading philosophy of science journal, such as *Philosophy of Science* or the *British Journal for the Philosophy of Science*.

In Axis 3, Guay and Kistler will edit a volume named *Comparing Dispositions* which will focus on the comparison of dispositions in different sciences.

Part of our production will bear on more than one axis: for instance, Kistler and Huneman will publish a volume on *Dispositions, mechanisms and compositionality*, which will gather results of research done in Axes 1 and 3.

We also plan the elaboration of a *Companion or Handbook to Metaphysics of Science*, which will be a reference for future research on the topic. We intend to invite, among others, the researchers that will have been taken part to our activities (workshops, conference, seminars) to collaborate to this *Companion*.

Finally, we will develop a comprehensive bibliography on metascience on the internet. Bibliographies (with links to available papers) already exist on other topics and are very popular among students and professionals. As an example of type of website we will create, let us mention David Chalmers' website on philosophy of mind (<http://consc.net/people.html>).

5. DESCRIPTION DU PARTENARIAT / CONSORTIUM DESCRIPTION

5.1. DESCRIPTION, ADÉQUATION ET COMPLÉMENTARITÉ DES PARTENAIRES / PARTNERS DESCRIPTION & RELEVANCE, COMPLEMENTARITY

The project is conducted by IHPST – Institut d'histoire et de philosophie des sciences et des techniques (CNRS, UMR 8590), which is the largest and most important institution in philosophy of science in Paris. It has a long tradition of collaboration with French and international scientists in all disciplines and a strong, collective research dynamics based on small active research groups. There is a large number of excellent PhD students at IHPST, as well as presently 5 postdoctoral research fellows from France, Italy, and the Netherlands. IHPST's seminars regularly host invited speakers in all areas of philosophy of science. Several international workshops take place every year.

5.2. QUALIFICATION DU COORDINATEUR DU PROJET / QUALIFICATION OF THE PROJECT COORDINATOR

Max Kistler's work has concentrated on a number of central concepts of the field of metaphysics of science. He has published a book on *Causation and Laws of Nature* (Routledge, 2006; original French edition, 1999) and is editor on collections on Causation (special issue of *Philosophie*, 2006), Dispositions (one book in English, two books in French, published in 2006 and 2007), Reduction and Emergence (special issue of *Synthese*, 2006, and special issue of *Philosophical Psychology*, 2009). He has published many papers in the field of metaphysics of science in journals such as *Erkenntnis*, *Dialectica*, *International Studies in the Philosophy of Science*, *Analysis* etc. His research strategy is based on the comparison of case studies in different sciences, especially in physics and psychology. He was trained as a physicist (Master's degree, university of Munich, 1991) and has been working on the philosophy of psychology since his PhD thesis at Institut Jean Nicod (CNRS, Paris, 1995). He has been responsible of a CNRS research project (ATIP – Jeune chercheur, 2002-2004) on reduction and emergence, and a RESCIF research project on reduction of cognition to neuroscience.

5.3. QUALIFICATION, RÔLE ET IMPLICATION DES PARTICIPANTS / QUALIFICATION AND CONTRIBUTION OF EACH PARTNER

Partenaire / partner	Nom / Name	Prénom / First name	Emploi actuel / Position	Discipline* / Field of research	Personne .mois** / PM	Rôle/Responsabilité dans le projet / Contribution to the project 4 lignes max.
Coordinateur/responsable	KISTLER	Maximilian	Professeur	philosophie	16.2	Coordinator and responsible of axis 3
Autres membres	GAYON	Jean	Professeur	philosophie	5.4	Responsible of axis 1
	GUAY	Alexandre	Maître de conférences	philosophie	10.8	Co-responsible of axis 2
	HUNEMAN	Philippe	Chargé de recherches	philosophie	5.4	Participates in axis 1 and 2, expertise in philosophy of biology
	LUDWIG	Pascal	Maître de conférences	philosophie	5.4	Participates in axis 1 and 3, expertise in philosophy of psychology
	PRADEU	Thomas	Maître de conférences	philosophie	14.4	Co-responsible of axis 2
	RUPHY	Stéphanie	Maître de conférences	philosophie	5.4	Participates in axis 2, expertise in philosophy of physics

* à renseigner uniquement pour les Sciences Humaines et Sociales

** à renseigner par rapport à la durée totale du projet

The Metascience project group has 7 members. 3 of them are members of the IHPST. These researchers are of different status and are at different points in their careers: two are professors (Gayon and Kistler), one is “chargé de recherche” (Huneman), four are “maîtres de conférence” (Guay, Ludwig, Pradeu and Ruphy). They are from different universities or centers: Paris 1 (Panthéon-Sorbonne: Gayon and Kistler), Université Paris 4 (Paris-Sorbonne: Ludwig and Pradeu), Université de Bourgogne (Guay), Université de Provence (Ruphy), and CNRS-IHPST (Huneman).

IHPST is the largest and most important institution in philosophy of science in Paris in France. It has a long tradition of collaboration with French and international scientists in all disciplines and a strong, collective research dynamics based on small active research groups. There is a large number of excellent PhD students at IHPST, as well as presently 5 postdoctoral research fellows from France, Italy, and the Netherlands. IHPST's seminars regularly host invited speakers in all areas of philosophy of science. Several international workshops take place every year.

A large majority of the members of the Metascience team are members (or associate members) of IHPST. An important and active subgroup has its focus on the philosophy of biology, composed of Jean Gayon, Philippe Huneman and Thomas Pradeu.

Jean Gayon is a historian and philosopher of biology; his research deals with genetics and evolutionary biology; besides *Darwinism's Struggle for Existence* (Cambridge UP, 1998), he published numerous papers on issues related to the Modern Synthesis and the concept of gene, but also on general philosophy of science. He currently leads the ANR program Evo-Eco, an interdisciplinary research on the conceptual transfers between economy and evolutionary biology, and has been leader of an ANR program on functions in biology and psychology (up to 2008). He is also the director of IHPST, and is France coordinator of the Montreal Paris Duke Toronto Consortium for the History & Philosophy of Biology (CHPB, description below). He supervises many theses on the philosophy of evolutionary biology and medicine. Besides research on the constitution of modern biology (*Métaphysique et Biologie*, 2008). **Philippe Huneman** published papers on emergence, function, adaptation and individuality (e.g. in *Philosophy of Science, Synthese*, etc.) in evolution and ecology. Member of the Scientific Committee of the Engineering program of the Ecology Institute of CNRS, he has run a project on the stability of ecosystems with ecologist Minus van Baalen (Paris 6), and a France Canada (FCRF) funded Research project on development and evolution with Denis Walsh (Toronto). Also coordinator of the CHPB, he also edits with Frederic Bouchard (Montreal) a book on issues in biological individuality based on symbiosis and evolutionary transitions studies (*From Groups to Individuals*, forthcoming at MIT Press). **Thomas Pradeu** is a philosopher of biology, specialized in immunology and developmental biology. He published several papers in international journals such as *Proceedings of the National Academy of Sciences USA, Science, The Lancet, Biology and Philosophy*, etc., especially on philosophical issues in immunology, as well as a book (*The Limits of the Self: Immunology and Biological Identity*, Oxford University Press, 2012). On this basis, he elaborates a theoretical view of biological individuality and of organisms.

Together, Gayon, Huneman, and Pradeu share an extended knowledge of philosophical issues in biology as well as of its history, since their expertise covers ecology (Huneman), evolutionary biology (Huneman, Gayon, Pradeu), development (Pradeu, Gayon), physiology (Gayon, Pradeu), genetics (Huneman, Gayon), etc. They organized together symposia in international conferences (e.g. PSA, ISHPSSB), and published together chapters in a reference book on evolutionary sciences (*Les mondes darwiniens*, Paris, 2010, tr. *Handbook of evolutionary thinking*, Springer, 2012). This general expertise is complementary with the expertise of philosophers of physics and of psychology. All share expertise and interest in general philosophy of science and metaphysics.

Three members of the group work mostly in the philosophy of physics. **Alexandre Guay** works mostly in history and philosophy of physics. He has published papers in physics, history and philosophy journals, notably in the *Biophysical journal, Perspectives on Science, Philosophy of Science* and *Studies in History and Philosophy of Modern Physics*. His current research focuses on different ontological problems in physics. An important part of **Stéphanie Rupy's** research is in general philosophy of science, where her focus is on natural kinds and scientific classification (especially in astrophysics, which is her main field of scientific expertise), reduction and unity vs. plurality of the sciences, models and simulations. She has published several papers on topics in the metaphysics of science, in *Philosophy of Science, Synthese, International Studies in the Philosophy of Science*. She is presently the Secretary of the French Société de philosophie des sciences.

A third group within the research team works in the philosophy of mind and psychology.

Max Kistler has explored the application of such general philosophical concepts as causation, law, disposition and reduction to various sciences, in particular physics and psychology. In various papers, he has compared the challenges that detailed analysis of cases of inter-level reduction (in particular: the reduction of thermodynamics in terms of statistical mechanics and the reduction of long-term memory in microbiological terms) raises for classical philosophical accounts of reduction. A special issue of *Philosophical Psychology* he has edited shows how the analysis of cognitive neuroscience has shaped the philosophical conception of the relations between different sciences that aim at explaining a complex system at different levels.

More recently, he has used the concepts of power and disposition to analyse an apparent paradox in the philosophy of perception, showing that these concepts are equally indispensable for the analysis of physical dispositions such as electrical conductivity.

Pascal Ludwig's research uses conceptual tools from the philosophy of language to study issues in the philosophy of mind, such as phenomenal consciousness and introspection. He is co-author of a book on S. Kripke, co-editor of a special issue of *The Monist* on Art and Mind, and editor of a collection on the Philosophy of Language. He is also co-author, with A. Barberousse and M. Kistler, of an introductory book on the philosophy of science. He has recently published a review chapter on emergence in a companion to the philosophy of science.

The Metascience group would be the largest French speaking group working on metaphysics of science. It will bring together leading researchers of different fields that have been working separately until now (though some members have already worked together, as we mentioned). The biggest payoff of this network is the diversity and complementarity of the team members while maintaining a clear unified intent of purpose. Such projects often lack the critical mass necessary to cover the various facets of such a broad theme. This team includes the best of what French scholarship has to offer on such topic and offers all the tools to provide a compelling account of metascience. Looking for example at biological side of our endeavour, we have impressive and world-recognized expertise in both philosophy and history of biology (e.g. Gayon), as well as leading expertise in philosophy of contemporary biology (e.g. Huneman, Pradeu). The same could be said with physics and psychology. Only in pooling such resources can we make genuine advances on such a difficult and timely topic. As could be seen by the description, every member has a specialty that is different from the others (even when working in the same field). We think that this will allow us to cover a very large portion of the domain of science, thereby avoiding the parochialism that individual expertise often unintentionally produces. As we said, this kind of project cannot be carried on by a single researcher, not even by a small group of researchers.

	Nom de la personne participant au projet / name	Personne . Mois / PM	Intitulé de l'appel à projets, source de financement, montant attribué / Project name, financing institution, grant allocated	Titre du projet : Project title	Nom du coordinateur / coordinator name	Date début & Date fin / Start and end dates
N°	GAYON, Jean	7.2	Programme blanc ANR	EVO-ECO	GAYON, Jean	1/1/2009 – 30/9/2012

6. JUSTIFICATION SCIENTIFIQUE DES MOYENS DEMANDÉS / SCIENTIFIC JUSTIFICATION OF REQUESTED RESSOURCES.

6.1. PARTENAIRE 1 / PARTNER 1 : TOTAL REQUESTED FUNDS : €244 588

For details of requested funds, see Appendix.

- **Personnel / Staff REQUESTED FUNDS : €143 901**

The post-doctoral research fellow will be hired for 36 months. He or she will work at IHPST in Paris and will provide organizational support for the activities of the teams. Among her or his tasks will be helping organising the workshops and final conference, and very importantly the creation and maintenance of the project website, which is essential not only to provide efficient tools of cooperation within the team but also for the dissemination of the results of our research. Moreover, the organisation of the workshops and conference requires administrative assistance for

short periods, which we estimate to amount to one month over the whole three-year period of the project.

Overall budget for the post-doctoral research fellow (36 months) and administrative assistance (1 month): €143 901.

• *Missions / Travel REQUESTED FUNDS : €71 280*

The workshops are essential for the success of the project because they will be the main occasions for direct exchange between all members of the team and international experts who will be invited as speakers. The budget for the workshops is an estimate of the travel costs (transportation and accommodation) of the invited speakers. Overall cost for three workshops (one for each axis) and the final conference : €41 310.

But it will also be very important to allow the project members to present their work at other conferences in the area of metaphysics of science, such as Philosophy of Science Association (PSA), Society for Philosophy of Science in Practice (SPSP), Society for the Philosophy of Psychology (SPP), International Society for the History, Philosophy and Social Study of Biology (ISHPSSB), or conferences organized by the Norwegian research project on Causation in science, and the German research project on the interface between science and metaphysics; many of these conferences take place in Canada and the US. Budget devoted to funding of the travel costs for members of the Paris team to such conferences: €18 000.

It will sometimes be essential to invite experts to speak in seminars of the project. Budget: €5000.

• *Autres dépenses de fonctionnement/Other expenses REQUESTED FUNDS : €20 000*

One of the aims of the project is to constitute a unique database on metaphysics of science. This justifies the budget devoted to buying books on the topic. Budget: €10000.

Scientific editors often require a financial contribution to publish collective work. We estimate our need for such funding with €10000.

7. RÉFÉRENCES BIBLIOGRAPHIQUES / REFERENCES

“State of the art” references (not members of the research team):

- Aizawa, K., Gillett, C. 2009. “The (multiple) realization of psychological and other properties in the sciences”. *Mind & Language*, 24(2): 181-208.
- Anderson, P.W. 1972. “More is Different: Broken Symmetry and the Nature of the Hierarchical Structure of Science”, *Science* 177 (4047): 393–396
- Armstrong, D.M. 1968. *A Materialist Theory of the Mind*. London: Routledge and Kegan Paul.
- Armstrong, D.M. 1977. “Beliefs as States.” In *Dispositions*, ed. Raimo Tuomela, 411-425. Dordrecht: Reidel.
- Armstrong, D.M. 2004. *Truth and Truthmakers*. Cambridge: Cambridge University Press.
- Batterman. 2001. *The Devil in the Details*. New York: Oxford University Press.
- Bedau, M. 1997. “Weak Emergence”, in James Tomberlin (ed.), *Philosophical Perspectives: Mind, Causation, and World*, vol. 11. Oxford: Blackwell, 375–399.
- Bedau M. and Humphreys P. 2008. *Emergence. Contemporary Readings in Philosophy and Science*, Cambridge: MIT Press.
- Bechtel, W., and J. Mundale. 1999. “Multiple Realizability Revisited: Linking Cognitive and Neural States.” *Philosophy of Science* 66:175-207.
- Bickle, J. 1998. *Psychoneural Reduction*. Cambridge (Mass.): MIT Press.
- Bickle, J. 2003. *Philosophy and Neuroscience: A Ruthlessly Reductive Account*. Dordrecht: Kluwer.
- Bird, A. 1998. “Dispositions and Antidotes.” *Philosophical Quarterly* 48:229-230.
- Bird, A. 2007. *Nature’s Metaphysics: Laws and Properties*. Oxford: Clarendon Press.

- Brading, K. & E. Castellani eds. 2003. *Symmetries in Physics: philosophical reflections*. Cambridge: Cambridge University Press.
- Brandon, R. 1988. "The levels of selection: a hierarchy of interactors", in H. Plotkin (ed.), *The Role of Behavior in Evolution*, Cambridge (MA), MIT Pr., pp. 51-71.
- Buss, L. 1987. *The Evolution of Individuality*. Princeton, N.J.: Princeton University Press.
- Carnap, R. 1931. "Die Überwindung der Metaphysik durch logische Analyse der Sprache." *Erkenntnis* 2:219-241.
- Carnap, R. 1936. "Testability and Meaning I." *Philosophy of Science* 3:419-471.
- Carnap, R. 1937. "Testability and Meaning II." *Philosophy of Science* 4:1-40.
- Carwright, N. 2007. *Hunting Causes and Using Them: Approaches in Philosophy and Economics*. Cambridge University Press.
- Castellani, E. ed. 1998. *Interpreting Bodies: classical and quantum objects in modern physics*. Princeton: Princeton University Press.
- Chalmers, D. 1996. *The Conscious Mind*. Oxford: Oxford University Press.
- Chalmers, D. 2001. ?????
- Chalmers, D. 2002. "Strong and Weak Emergence" reed. in P. Clayton and P. Davies, eds. (2006) *The Re-Emergence of Emergence*. Oxford: Oxford University Press.
- Clark, A. 1993. *Sensory Qualities*. Oxford: Oxford University Press.
- Craver, C.F. 2001. "Role Functions, Mechanisms and Hierarchy." *Philosophy of Science* 68:53-74.
- Craver, C.F. 2002. "Interlevel Experiments and Multilevel Mechanisms in the Neuroscience of Memory." *Philosophy of Science* 69 (Proceedings): S83-S97.
- Craver, C.F. 2007. *Explaining the Brain: Mechanisms and the Mosaic Unity of Neuroscience*. Oxford: Oxford University Press.
- Craver, C., & Bechtel, W. 2007. "Top-down causation without top-down causes." *Biology and Philosophy*, 22: 547-563.
- Craver, C.F., and L. Darden. 2001. "Discovering Mechanisms in Neurobiology: The Case of Spatial Memory." In *Theory and Method in the Neurosciences*, ed. P.K. Machamer, R. Grush, and P. McLaughlin, 112-137. Pittsburgh, PA: University of Pittsburgh Press.
- Darden, L., and N. Maull. 1977. "Interfield Theories." *Philosophy of Science* 44:43-64.
- De Gardelle, V., J. Sackur, and S. Kouider. 2009. "Perceptual illusions in brief visual presentations." *Consciousness and Cognition* 18:569-577.
- Debs, T.A., and M.L.G. Redhead. 2007. *Objectivity, Invariance, and Convention: symmetry in physical science*. Harvard University Press.
- Duhem, P. 1906/1981. *La Théorie physique*. Repr. Paris: Vrin.
- Dupré J. 1993. *The Disorder of Things: Metaphysical Foundations of the Disunity of Science*. Cambridge, MA: Harvard University Press.
- Dupré J., and M.A. O'Malley. 2007. "Metagenomics and biological ontology." *Studies in History and Philosophy of Biological and Biomedical Sciences* 38:834-846.
- Dupré, J., and M.A. O'Malley. 2009. "Varieties of living things: Life at the intersection of lineage and metabolism." *Philosophy & Theory in Biology* 1.
- Eldredge, N. 1985. *Unfinished Synthesis: Biological Hierarchies and Modern Evolutionary Thought*, New York, Oxford University Press.
- Eldredge, N. & Salthe, S.N., 1984. "Hierarchy and Evolution", in: R. Dawkins & M. Ridley, eds., *Oxford Surveys in Evolutionary Biology* 1, 182-206.
- Ellis, B. 2001. *Scientific Essentialism*. Cambridge: Cambridge University Press.
- Feyerabend, P.K. 1962. "Explanation, Reduction and Empiricism." In *Minnesota Studies in the Philosophy of Science III*, ed. H. Feigl and G. Maxwell, 28-97. Minneapolis: University of Minnesota Press.

- Fodor, J.A. 1974/1981. "Special Sciences, or the Disunity of Science as a Working Hypothesis." In *Representations*, ed. J.A. Fodor. Cambridge (Mass.): MIT Press.
- Fodor J.A. 1997. "Special sciences: still autonomous after all these years", in J.A. Tomberlin (ed.), *Mind, causation and world (Philosophical Perspectives, Vol. 11)*, Oxford: Blackwell, 149–163.
- Fodor, J.A. 1998. "Look !", review of E.O. Wilson, *Consilience: The Unity of Knowledge*, New York: Knopf, 1998, *London Review of Books*, 20 (21), 29 October 1998, p. 3-6.
- Folse, H.J. & Roughgarden, J., 2010. What is an Individual Organism? A Multilevel Selection Perspective. *The Quarterly Review of Biology* 85(4): 447-472.
- French, S. & D. Krause 2006. *Identity in Physics: an historical, philosophical and formal analysis*. Oxford: Oxford University Press.
- Galison, P. 1997. *Image and Logic: a material culture of microphysics*. Chicago: The University of Chicago Press.
- Giere, R. 1988. *Explaining Science*. Chicago: University of Chicago Press.
- Gilbert, S. F. 2002. "The genome in its ecological context." *Annals of the New York Academy of Science* 981:202-218.
- Gillett, Carl 2003. "The Metaphysics of Realization, Multiple Realization and the Special Sciences." *Journal of Philosophy* 100:591-603.
- Gillett, C. 2007. "Understanding the New Reductionism: The Metaphysics of Science and Compositional Reduction." *Journal of Philosophy* 104:193-216.
- Gillett C. 2010. "Moving beyond the subset model of realization: The problem of qualitative distinctness in the metaphysics of science." *Synthese*, 177:165–192.
- Godfrey-Smith P. 2009. *Darwinian populations*. New York: Oxford University Press.
- Goodman, N. 1955/1973. *Fact, Fiction, and Forecast*. Repr. Indianapolis: Bobbs-Merrill.
- Graff, D. 2001. "Phenomenal Continua and the Sorites." *Mind* 110:905-935.
- Grantham, T.A. 2004. "Conceptualizing the (Dis)Unity of Science." *Philosophy of Science* 71:133-155.
- Hacking, I. 1983. *Representing and Intervening*. Cambridge: Cambridge University Press.
- Hacking, I. 1993. "Working in a new world: The taxonomic solution." In *World Changes*, ed. Paul Horwich. Cambridge, Mass.: The MIT Press.
- Hacking, I. 2009. *Scientific Reason*. Taipei: The NTU Press.
- Hahn, H., O. Neurath, and R. Carnap. 1929. *Wissenschaftliche Weltauffassung - Der Wiener Kreis*. Wien: Artur Wolf Verlag.
- Halvorson, H., and R. Clifton. 2002. "No Place for Particles in Relativistic quantum Theories?" *Philosophy of science* 69:1-28.
- Harré R. and E.H. Madden. 1975. *Causal Dispositions*, Oxford, Blackwell.
- Hempel, C.G. 1935/2002. "Analyse logique de la Psychologie." In *Philosophie de l'esprit, vol. I: Psychologie du sens commun et sciences de l'esprit*, ed. Denis Fisette and Pierre Poirier. Vrin.
- Hempel, C.G. and P. Oppenheim. 1948/1965. "Studies in the Logic of Explanation." In *Aspects of Scientific Explanation*, ed. C.G. Hempel, 245-290. Repr. New York: The Free Press.
- Hovda, P. 2008. "Quantifying weak emergence." *Minds & Machines*: 18, 461–473.
- Hull D.L. 1978. "A Matter of individuality." *Philosophy of Science* 45:335-360.
- Hull D.L. 1980. "Individuality and selection." *Annual Review of Ecology and Systematics* 11:311-332
- Hull, D. 1981. "Units of evolution: a metaphysical essay", in U.L. Jensen and R. Harré", *The Philosophy of Evolution*, Brighton: Harvester Press, pp.-23-44.
- Hull, D. 1988. *Science as a Process: an Evolutionary Account of the Social and Conceptual Development of Science*. Chicago: University of Chicago Press.
- Hull, D. 1989. *The Metaphysics of Evolution*. New York: State University of New York Press.

- Hull, D. 1992. "Individual." In *Keywords in Evolutionary Biology*, ed. E. Fox-Keller and E. Lloyd, 181-187. Cambridge, MA: Harvard University Press.
- Jackson, F. 1982. "Epiphenomenal Qualia." *Philosophical Quarterly* 32:127-136.
- Jackson, F. 1998. *From Metaphysics to Ethics*. Oxford: Clarendon Press.
- Johnston, M. 1992. "How to Speak of the Colors." *Philosophical Studies* 68:221-263.
- Kim, J. 1992. "Multiple Realization and the Metaphysics of Reduction." *Philosophy and Phenomenological Research* 52:1-26.
- Kim, J. 1998. *Mind in a Physical World*. Cambridge (Mass.): MIT Press.
- Kim, J. 1999. "Making sense of emergence". *Philosophical Studies*, 95: 3-36.
- Kim, J. 2005. *Physicalism, or Something Near Enough*. Princeton: Princeton University Press.
- Kuhn, T. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
- Ladyman, J. and D. Ross. 2007. *Every Thing Must Go: Metaphysics Naturalized*. Oxford University Press.
- Laughlin, Robert (2005), *A Different Universe: Reinventing Physics from the Bottom Down*. New York: Basic Books.
- Lewis, D. 1972/1991. "Psychophysical and Theoretical Identifications." In *The Nature of Mind*, ed. D. Rosenthal. Repr. Oxford University Press.
- Lipton, P. 1999. "All Else Being Equal." *Philosophy* 74:155-168.
- Mach, E. 1883. *Die Mechanik in ihrer Entwicklung historisch-kritisch dargestellt*. Leipzig: Brockhaus.
- Machamer, P., L. Darden & C.F. Craver. 2000. "Thinking About Mechanism", *Philosophy of Science* 67(1):1-25.
- MaynardSmith and Szathmary. 1995. *The Major Transitions in Evolution*. Oxford; New York: W.H. Freeman Spektrum.
- Maudlin, T. 2007. *The Metaphysics Within Physics*. New York: Oxford University Press.
- Maxwell, G. 1962. "The Ontological Status of Theoretical Entities." In *Scientific Explanation, Space, and Time*, ed. H. Feigl and G. Maxwell, 3-15. Minnesota Studies in the Philosophy of Science, vol. 3.
- Maynard Smith and Szathmary. 1995. *The Major Transitions in Evolution*, New-York: Oxford University Press,
- McCauley, R.N. 1996. "Explanatory Pluralism and the Co-evolution of Theories in Science." In *The Churchlands and their Critics*, ed. R.N. McCauley, 17-47. Cambridge MA: Blackwell.
- Michod, R.E. 1999. *Darwinian Dynamics: Evolutionary Transitions in Fitness and Individuality*. Princeton: Princeton University Press.
- Molnar, G. 1999. "Are Dispositions Reducible?" *Philosophical Quarterly* 49:1-16.
- Molnar, G. 2003. *Dispositions. A Study in Metaphysics*. Oxford: Oxford University Press.
- Morganti, M. 2009. Inherent Properties and Statistics with Individual Particles in Quantum Mechanics. *Studies in History and Philosophy of Modern Physics* 40(3):223-231.
- Moulines, C.U. 2006. "Ontology, reduction, emergence: A general frame." *Synthese* 151:313-323.
- Mumford, S. 1998. *Dispositions*. Oxford: Oxford University Press.
- Mumford, S. 2006. "The Ungrounded Argument." *Synthese* 149:471-489.
- Nagel, E. 1961. *The Structure of Science*. London: Routledge and Kegan Paul.
- Neander, K. 1991. "Functions as Selected Effects: The Conceptual Analysts Defence." *Philosophy of Science* 58:169-184.
- Okasha, S. 2006. *Evolution and the Levels of Selection*. New York: Oxford University Press.
- Piaget, J. 1950. *Introduction à l'épistémologie génétique. Tome 3*, Paris: Presses Universitaires de France.
- Polger, T. 2004. *Natural Minds*. Cambridge, MA: MIT Press.

- Popper, K. R. 1957a. "The Aim of Science." *Ratio* 1:4-35.
- Popper, K.R. 1957b. "The propensity interpretation of the calculus of probability, and the quantum theory." In *Observation and Interpretation*, ed. S. Körner, 65-70. London: Butterworth.
- Prior, E.W., R. Pargetter and F. Jackson. 1982. "Three Theses about Dispositions." *American Philosophical Quarterly* 19:251-257.
- Putnam, H. 1967/1971. "The Nature of Mental States." In *Materialism and the Mind-Body-Problem*, ed. David Rosenthal. Repr. Englewood Cliffs, NJ: Prentice Hall.
- Quine, W. 1953/1980a. "On what there is." In *From a Logical Point of View*, 1-19. Repr. 2nd edition, Cambridge, MA: Harvard University Press.
- Quine, W. 1953/1980b. "Two Dogmas of Empiricism." In *From a Logical Point of View*, 20-46. Repr. Cambridge, MA: Harvard University Press, 2nd edition.
- Quine, W.V.O. 1971. *The Roots of Reference*. LaSalle, Ill.: Open Court.
- Raffman, D. 2000. "Is Perceptual Indiscriminability Nontransitive?" *Philosophical Topics* 28:153-175.
- Rosenberg A. 1994. *Instrumental biology or the disunity of science*. Chicago: University of Chicago Press.
- Ryle, G. 1949/2000. *The Concept of Mind*. Repr. London: Penguin Books.
- Salthé, S. N., 1985. *Evolving Hierarchical Systems*, New York, Columbia University Press.
- Schaffner, K. 1993. *Discovery and Explanation in Biology and Medicine*. Chicago University Press, Chicago.
- Schrenk, M. 2007. "Can Capacities Rescue us from Ceteris Paribus Laws?", in *Dispositions and Causal Dispositions*, ed. M. Kistler and B. Gnassounou, p. 221-247. Aldershot: Ashgate.
- Sellars, W. 1963. *Science, Perception and Reality*. London: Routledge & Kegan Paul
- Shalizi C. and Moore C. 2003. "What Is a Macrostate? Subjective Observations and Objective Dynamics ", arXiv:cond-mat/0303625v1.
- Shapiro, L. 2000. "Multiple Realizations." *Journal of Philosophy* 97:635-654.
- Shapiro, L. 2004. *The Mind Incarnate*. Cambridge, MA: MIT Press.
- Shepard, R. 1962. "The Analysis of Proximities: Multidimensional Scaling with an Unknown Distance Function." *Psychometrika* 27:125-140 and 219-246.
- Shepard, R. 1974. "Representation of Structure in Similarity Data: Problems and Prospects." *Psychometrika* 39:373-421.
- Shoemaker, S. 2007. *Physical Realization*. New York: Oxford University Press.
- Silberstein, M. 1998. "Emergence and the Mind/Body Problem," *Journal of Consciousness Studies* 5 : 464–82.
- Silberstein, M. 2002. "Reduction, Emergence and Explanation", in M. Silberstein and P. Machamer (eds.), *Blackwell Guide to the Philosophy of Science*. Oxford: Blackwell, 80–107.
- Sklar, L. 1993. *Physics and Chance*. Cambridge: Cambridge University Press.
- Sperling, G. 1960. "The information available in brief visual presentations" *Psychological Monographs: General and Applied* 74(11):1-29.
- Stotz, K., P. E. Griffiths, et al. 2004. "How scientists conceptualise genes: An empirical study." *Studies in History & Philosophy of Biological and Biomedical Sciences* 35(4):647-673.
- Strawson, P.F. 1959. *Individuals*. London: Methuen.
- Suarez, M. ed. 2010, *Probabilities, Causes, and Propensities in Physics*, Heidelberg: Springer.
- van Fraassen, B.C. 1980. *The Scientific Image*. Oxford: Clarendon Press.
- van Fraassen, B.C. 2008. *Scientific Representation: Paradoxes of Perspective*. Oxford University Press.
- Wheeler, Q. D. and R. Meier eds. 2000. *Species Concepts and Phylogenetic Theory*. New York: Columbia University.

- Weinberg, S. 1987. "Newtonianism, Reductionism and the Art of Congressional Testimony", in *Nature*, Vol. 330, No. 6147, December 1987, 433–437.
- Wilson, J. 1999. *Biological individuality: The identity and persistence of living entities*. Cambridge & New York: Cambridge University Press.
- Wilson, R.A. 2005. *Genes and the agents of life: The individual in the fragile sciences, biology*. Cambridge & New York: Cambridge University Press.
- Wimsatt, W. 1974. "Complexity and Organization," in K. F. Schaffner and R.S. Cohen (eds.), *PSA 1972, (Boston Studies in the Philosophy of Science, vol. 2)*. Dordrecht, Holland: Reidel, 67–86.
- Wimsatt, W. 1997, "Aggregation: Reductive Heuristics for Finding Emergence", *Philosophy of Science* 64: S372–S384.
- Wolfe C. and Terada M. 2008. "The Animal Economy as Object and Program in Montpellier Vitalism " *Science in context*, 21,4: 537 -579

Publications by members of the research team:

- Barberousse, A. 2007. "Are specific heats dispositions ?" In *Dispositions and Causal Powers*, ed. M. Kistler, and B. Gnassounou, 271-282.
- Barberousse A. and P. Ludwig. 2008. "Models as fictions." In *Fictions in Science Philosophical Essays on Modeling and Idealization*, ed. Mauricio Suárez. New York: Routledge.
- Braillard, P.-A., A. Guay, C. Imbert, and T. Pradeu. 2011. "Une objectivité kaléidoscopique: construire l'image scientifique du monde." *Philosophie* 110: 46-71.
- Carosella E.D. and T. Pradeu. 2010. *L'identité, La Part de l'autre. Philosophie et immunologie*. Paris: Odile Jacob.
- Gayon J. 1993 "La biologie entre loi et histoire", *Philosophie*, 38: 30-57.
- Gayon J. 1996. "The Individuality of the Species: A Darwinian Theory? - From Buffon to Ghiselin, and Back to Darwin", *Biology and Philosophy* 11: 215-244.
- Gayon J. 1998. "La marginalisation de la forme dans la biologie de l'évolution", *Bulletin de la Société d'histoire et d'épistémologie des sciences de la vie*, 5(2):133-168.
- Gayon J. 2000. "From Measurement to Organization : A Philosophical Scheme for the History of the Concept of Heredity", in *The Concept of the Gene in Development and Evolution : Historical and Epistemological Perspectives*, Peter Beurton, Raphael Falk and Hans-Jorg Rheinberger (eds.), Cambridge, Cambridge University Press, pp. 69-90.
- Gayon J. 2002. "Y a-t-il un concept biologique de la race ?", *Annales d'histoire et de philosophie du vivant*, 6: 155-176.
- Gayon J. 2003. "Naturalisation de la culture, naturalisation de la philosophie : enjeux et limites", in Wolfgang Buschlinger & Christoph Lütge (eds.), *Kalblütlig. Philosophie von einem rationalen Standpunkt. Festschrift für Gerard Vollmer zum 60. Geburtstag*, Stuttgart, S. Hirzel Verlag, pp. 243-275.
- Gayon J. 2005. "Chance, Explanation, and Causation in Evolutionary Theory », *History and Philosophy of the Life Sciences*, 27 (2005): 387-397.
- Gayon J. 2006. "Les biologistes ont-ils besoin du concept de fonction? Perspective philosophique", *C. R. Palevol*, 5 (2006): 479-487 (Paris, Académie des Sciences, éditions Elsevier).
- Gayon J. 2006. "Le concept d'individualité dans la philosophie biologique de Georges Canguilhem", in *L'épistémologie française 1830-1970*, ss dir. Michel et Bitbol & Jean Gayon, Paris, Presses Universitaires de France, pp. 431-463.
- Gayon J. 2007. « Karl Pearson ou les enjeux du phénoménalisme dans les sciences biologiques vers 1900 », in *Conceptions de la science: Hier, aujourd'hui et demain. Hommage à Marjorie Grene*, ss dir. de J. Gayon & R.M. Burian et avec la collaboration de

- M. C. Lorne, Bruxelles, Ousia, 2007, pp. 305-324.
- Gayon J. 2008. « L'explication fonctionnelle dans la psychologie et l'épistémologie piagétienne », in *Les fonctions en psychologie*, ss dir. F. Parot, Bruxelles, Mardaga, 2008, pp. 139-160.
 - Gayon J. 2008. « Les espèces et les taxons monophylétiques sont-ils des individus? », in P. Ludwig & T. Pradeu (éds.), *L'individu. Perspectives contemporaines*, Paris, Vrin, 2008, pp. 128-150.
 - Gayon J. 2009. « Fonction », en coll. Avec Armand de Ricqlès, in *Les mondes darwiniens. L'évolution de l'évolution*, T. Heams, P. Huneman, G. Lecointre & M. Silberstein (éds.), Paris, Editions Syllepse, 2009, pp. 105-125.
 - Gayon J. 2010. « Raisonement fonctionnel et niveaux d'intégration en biologie », in *Les fonctions : des organismes aux artefacts*, ss dir. J. Gayon & A. de Ricqlès, Paris, Presses Universitaires de France, 2010, pp. 125-138.
 - Gayon, 2010. « Réflexions sur l'individualité biologique », in Joseph Kouneiher (éd.), *Vers une nouvelle philosophie de la nature. Actualités mathématiques, physiques et biologiques*, Paris, Hermann, pp. 215-222.
 - Gnassounou B. and M. Kistler eds. 2005. *Causes, pouvoirs, dispositions en philosophie. Le retour des vertus dormitives*. Paris: Presses Universitaires de France.
 - Gnassounou B., and M. Kistler, eds. 2006. *Les dispositions en philosophie et en sciences*. Paris: CNRS Editions.
 - Guay, A. 2007. "Appareil, image et particule." In *Appareil et Intermédialité*, ed. J.-L. Déotte, M. Froger, and S. Mariniello, 97-120. Paris: L'Harmattan.
 - Guay, A. 2008. "Essay Review: Conceptual Foundations of Yang-Mills Theories." *Studies in History and Philosophy of Modern Physics* 39(3): 687-693.
 - Guay, A. 2008. "A Partial Elucidation of the Gauge Principle." *Studies in History and Philosophy of Modern Physics* 39(2):346-363
 - Huneman, P. 1998. *Bichat. La vie et la mort*. Paris: PUF.
 - Huneman, P. 2008a. *Métaphysique et biologie*. Paris: Kimé.
 - Huneman P., and P. Humphreys. 2008b. "Dynamical Emergence and Computation: An Introduction." *Minds and Machines* 18:425-430. Ajouter lettre après 2008, ou bien supprimer
 - Huneman P. 2008c. "Emergence and adaptation ", *Minds and Machines* 18:493-520.
 - Huneman P. 2008d. "Combinatorial vs. computational emergence: emergence made ontological?" *Philosophy of science* 75:595-607.
 - Huneman P. 2010a "Determinism and predictability: lessons from computational emergence." *Synthese*, On-Line First.
 - Huneman P. 2010b. "Topological explanations and robustness in biological sciences." *Synthese* 77: 213-245.
 - Huneman P. 2010c. "The conceptual foundations of ecological engineering. Stability, individuation, ethics." In *Ecological engineering*, ed. S. Barot. Amsterdam: Elsevier.
 - Huneman P. 2011. "Natural sciences" In *The Cambridge History of 19th century philosophy*. ed. Allen Wood. Cambridge: Cambridge University Press.
 - Kistler, M. 1998. "Reducing Causality to Transmission." *Erkenntnis* 48:1-24.
 - Kistler, M. 1999. "Causes as events and facts." *Dialectica* 53:25-46.
 - Kistler, M. 1999. "Multiple Realization, Reduction, and Mental Properties." *International Studies in the Philosophy of Science* 13:135-149.
 - Kistler, M. 2000. "Réduction fonctionnelle et réduction logique." *Philosophiques* 27:27-38.
 - Kistler, M. 2001. "Causation as transference and responsibility." In *Current Issues in Causation*, ed. Wolfgang Spohn, Marion Ledwig, and Michael Esfeld, 115-133. Paderborn: Mentis.

- Kistler, M. 2001. "Le concept de génidentité chez Carnap et Russell." In *Carnap et la construction logique du monde*, ed. Sandra Laugier, 163-188. Paris: Vrin.
- Kistler, M. 2002. "The Causal Criterion of Reality and the Necessity of Laws of Nature." *Metaphysica* 3:57-86.
- Kistler, M. 2002. "Erklärung und Kausalität." *Philosophia naturalis* 39(1):89-109.
- Kistler, M. 2003. "Laws of Nature, Exceptions and Tropes." *Philosophia scientiae* 7:189-219.
- Kistler, M. 2004. "Some problems for Lowe's Four-Category Ontology." *Analysis* 64:146-151.
- Kistler, M. 2004. "Le combinatorialisme et le réalisme nomologique sont-ils compatibles ?" In *La Structure du monde: objets, propriétés, états de choses*, ed. J.-M. Monnoyer, 199-221. Paris: Vrin.
- Kistler, M. 2005. "Necessary Laws" In *Nature's Principles*, ed. Jan Faye, Paul Needham, Uwe Scheffler, and Max Urchs, 201-227. Dordrecht: Springer.
- Kistler, M. 2005. "Réduction « rôle-occupant », réduction « micro-macro », et explication réductrice a priori." *Dialogue: Canadian Philosophical Review* 44:225-248.
- Kistler, M. 2005. "Is Functional Reduction Logical Reduction?" *Croatian Journal of Philosophy* 5:219-234.
- Kistler, M. 2005. "Lowe's Argument for Dualism from Mental Causation." *Philosophia* (Philosophical Quarterly of Israel) 33:319-329.
- Kistler, M. 2006. *Causation and Laws of Nature*. London: Routledge.
- Kistler, M. 2006. "La causalité comme transfert et dépendance nomique." *Philosophie* 89:53-77.
- Kistler, M. ed. 2006. "New Perspectives on Reduction and Emergence in Physics, Biology, and Psychology." *Synthese* 151(3).
- Kistler, M. 2006. "Reduction and Emergence in the Physical Sciences: Reply to Rueger." *Synthese* 151(3):347-354.
- Kistler, M. 2006. "The Mental, the Macroscopic, and their Effects." *Epistemologia* 29:79-102.
- Kistler, M. 2006. "Lois, exceptions et dispositions." In *Les dispositions en philosophie et en sciences*, ed. Bruno Gnessounou and Max Kistler, 175-194. Paris: CNRS Editions.
- Kistler, M. 2007. "The Causal Efficacy of Macroscopic Dispositional Properties." In *Dispositions and Causal Powers*, ed. Max Kistler and Bruno Gnessounou, 103-132. Aldershot: Ashgate.
- Kistler, M. ed. 2009. *Philosophical Psychology* 22(5), special issue: "Cognition and Neurophysiology: Mechanism, Reduction, and Pluralism".
- Kistler, M. 2009. "Mechanisms and Downward Causation." *Philosophical Psychology* 22:595-609.
- Kistler, M. 2010. "Causation Across Levels, Constitution, and Constraint." In *EPSA Philosophical Issues in the Sciences : Launch of the European Philosophy of Science Association*, ed. Mauricio Suárez, Mauro Dorato, Miklós Rédei, 141-151. Springer.
- Kistler, M. and B. Gnessounou, eds. 2007. *Dispositions and Causal Powers*. Aldershot: Ashgate.
- Ludwig, P. and F. Dreapeau-Contim. 2005. *Saul Kripke. Référence et modalités*. Presses Universitaires de France.
- Ludwig P. and T. Pradeu eds. 2008. *L'Individu. Perspectives contemporaines*. Paris: Vrin.
- Pradeu T. 2009. *Les Limites du soi. Immunologie et identité biologique*. Montréal: Presses Universitaires de Montréal; Paris: Vrin.
- Pradeu T. 2009. "Immune System: "Big Bang" in Question." *Science* 325:393.
- Pradeu T. 2010. "What is an organism? An immunological answer." *History and Philosophy of the Life Sciences* 32:247-268.

- Pradeu T. 2012a. *The Limits of the Self: Immunology and Biological Identity*. New York: Oxford University Press.
- Pradeu T. 2012b. A Mixed Self: The Role of Symbiosis in Development. *Biological Theory* 6(1).
- Pradeu T. and E.D. Carosella. 2006. "On the definition of a criterion of immunogenicity." *Proceedings of the National Academy of Sciences USA* 103(47):17858-61.
- Pradeu T. and E.D. Carosella. 2006. "The Self Model and the Conception of Biological Identity in Immunology." *Biology and Philosophy* 21(2):235-252.
- Ruphy, S. 2003. "Is the world really 'dappled'? A response to Cartwright's charge against "cross-wise" reduction." *Philosophy of Science* 70:57-67.
- Ruphy, S. 2005. "Why metaphysical abstinence should prevail in the debate on reductionism." *International Studies in the Philosophy of Science* 19:105-121.
- Ruphy, S. 2006. "Ontology relativized: Reply to Moulines." *Synthese* 151:325-330.
- Ruphy, S. 2009. "Unité ou pluralité des sciences: nouvelles questions, nouveaux enjeux." In *L'unité des sciences aujourd'hui*, ed. T. Martin, 109-120. Vuibert.
- Ruphy, S. 2010. "Are Stellar Kinds Natural Kinds? A Challenging Newcomer in the Monism/Pluralism and Realism/Antirealism Debate." *Philosophy of Science* 77:1109-1120.
- Ruphy, S. 2011 "From Hacking's plurality of styles of scientific reasoning to "foliated" pluralism, a philosophically robust form of ontologico-methodological pluralism." *Philosophy of Science*.
- Samadi, S. and A. Barberousse. 2006. "The Tree, the Network and the Species." *The Biological Journal of the Linnean Society* 89(3):509-522.