Varieties of Interdisciplinarity and of Scientific Progress

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October 2007

What is interdisciplinarity? What to make of it? What forms does it take? What drives it? The remarks to follow seek to offer a relatively broad overview of selected key concepts and key issues that together help identify and assess the very complex and non-unitary phenomenon of interdisciplinarity. In the literature on interdisciplinarity, there has been a pressing need for more systematic and elaborate accounts. Even if very sketchy, what follows is an attempt to take a step or two towards that direction. Rather than anything final and complete and detailed, I submit a programmatic outline that requires follow-up investigations by way of further conceptual clarifications and empirical case studies.

Excitement and frustration

Today, interdisciplinarity is again a hot topic of talk by various agents. Scientists, students, educators, university administrators, extra-academic powers -- they all talk and act from their own perspectives with varying perceptions and stakes with respect to interdisciplinarity. There is a lot of enthusiasm around it, but at the same time, disillusion and disappointment are common. The rhetoric of interdisciplinarity flourishes and optimistic initiatives to enhance it abound. Yet there are familiar difficulties with creating workable and desired forms of it; with standards of evaluation; with its incorporation into prevailing (disciplinary) academic structures. Yet it happens, and always has - and will.

Rival images, complementary virtues

Discussions on disciplines and interdisciplinarity tend to be governed by geographic or territorial images and metaphors: we talk about research areas and fields of inquiry,
boundaries between disciplines as well as crossing and bridging them, etc. In the conversations on interdisciplinarity, disciplinarity often carries the connotations of being static, closed, conservative, elitist, narrow, loath to engage in interaction and innovation. In contrast, interdisciplinarity is characterised as dynamic, open, progressive, flexible, democratic, relevant, creative, collaborative and innovative.

From a different vantage point, the virtues are distributed otherwise, disciplinarity being the home of rigour, competence, order, stringent standards of quality, whereas interdisciplinarity struggles with vagueness, sloppiness, dilettantism, floating standards. This suggests that the apparently rival images of the two actually convey a picture of complementarity between the two. This is fortified by the observation that disciplinary specialization, on the one hand, and interdisciplinary crossing and bridging, on the other, are complementary, they mutually reinforce one another (cf Weingart 2000).

**Integration and breadth**

Note that the catchwords ‘integration’ and ‘unification’ are often conflated with those of ‘wholism’ and ‘breadth’ or ‘comprehensiveness’ – all of these supposedly being among the virtues of interdisciplinarity. But there is no necessary connection there. A highly unified or integrated interdisciplinary field or piece of research may be very narrow in its scope. It may be just another new tiny niche, a narrow specialty that tightly integrates ingredients from numerous disciplines. On the other hand, a field or discipline with apparently narrow and simple theoretical resources may turn out to be very expansive, with a growing range of applications across disciplinary boundaries. Thus, interdisciplinarity does not imply breadth, nor does disciplinary simplicity imply narrow scope.

**Neglected issues**

There is more, but I would like here to point out just two sets of issues that have received insufficiently detailed attention in the discussions on interdisciplinarity. One theme is the shop-floor intellectual mechanisms of interdisciplinary encounter. What role is played, and how exactly, by various cognitive elements of workaday scientific practice – such as
theories and models, methods and techniques, research questions and explanatory strategies - in enhancing, inhibiting, and shaping interdisciplinarity? The other major gap relates to the precise concepts used for expressing normatively desirable processes and outcomes commonly attributed to interdisciplinarity. What exactly is the promise of innovation and creativity and whatever other other desirable achievements one believes are enhanced by interdisciplinarity? Given that interdisciplinarity comes in so many sorts that have little to do with one another, the issue of promised progress requires close scrutiny.

**Contestable concept**

Interdisciplinarity is a contestable concept *descriptively*: it is burdened by deep ambiguities (what are we talking about?). It is also contestable *normatively*: there are rival assessments of the phenomenon (what are we to make of it?). The cures are obvious: 

*Cure 1*: clarify the key concepts!
*Cure 2*: look at it empirically!
*Cure 3*: set standards of normative assessment!

Here I take Cure 3 to require distinguishing various notions of progress that might be attributable to interdisciplinary inquiry. This seems a natural step to take given that certain dominant ideologies of interdisciplinarity link it with promises of progress as a recommendable norm. The adoption of all three cures will highlight variety as a feature of interdisciplinarity: it comes in different versions, there are different concepts of it, and its progressiveness is to be determined case by case.

**Vertical and horizontal relations**

One way to start sorting out the various kinds and dimensions of interdisciplinarity is to distinguish between vertical and horizontal relations between disciplines. As the story goes, there are *vertical relations between levels* in the World (atoms - molecules - brains - minds – institutions), and there are parallel vertical relations in Science (physics - chemistry - biology - psychology - social sciences). As for the upper layers of the latter, contemporary developments in interdisciplinarity involve relations between the Social sciences - Experimental psychology - Cognitive science – Neurobiology. There are also
horizontal relations within levels, such as between Economics - Political science - Sociology - Law - Anthropology - Human geography etc. (Needless to say – yet a pressing need to do something about it – there are problems with the precise identity of ‘level’. For example, do ‘micro’ social sciences and ‘macro’ social sciences constitute different levels?)

**Philosophy of science on interdisciplinarity**

Philosophy of science has traditionally focused on vertical issues, such as those of unity of science by reduction between ‘levels’, as well as those of ‘special sciences’, supervenience, multiple realizability, and emergence. In contemporary real-world developments in science, other issues seem more pressing, and they have mostly been neglected by the philosophy of science. These include horizontal ‘same-level’ relationships between disciplines; vertical ‘cross-level’ relationships other than reduction/supervenience/emergence; the current dynamics of niche-seeking problem-solving interdisciplinarity; and the social epistemology of interdisciplinarity.

**Discipline 1: meanings**

Interdisciplinarity is parasitic upon there being disciplines, thus serious attention must be paid to the concept of discipline. Dictionaries offer two related meanings. First, a discipline is normative structure imposed upon an activity, whereby the activity becomes disciplined. It is a set of sanctioned rules as to how to behave oneself: this is a matter of principles, standards, conventions, shared goals, prescribed styles, strategies to be followed, institutionalised power, internal control and external gate-keeping.

Second, a discipline is a circumscribed academic forum of research and education, with a coordinated system of concepts, theories, methods, questions, established facts, canonical convictions, traditions, degrees, accreditations, annual conferences, leading journals. One may then try to get further by invoking metaphors that express illuminating analogies, such as disciplines akin to nation states or to cartels. For example, Stephen Turner (2000) envisages disciplines as cartels that aim at producing and employing graduates in a protected academic market.
Discipline 2: aspects
Disciplines are complex epistemic institutions with numerous aspects. These aspects are important to recognise in order to understand the multiple ways in which disciplines accomplish the tasks of coordination, and in which they connect to one another. I distinguish three aspects:

The Intellectual aspect consists of a shared agenda, goals, constitutive questions, concepts, theories, methods, standards.

The Organizational aspect consists of university departments, chairs and other jobs, educational programmes and degrees, certifications and affiliations, centres and institutes, associations, conferences, journals.

The Mental aspect comprises things such as the sense of group identity, loyalty and commitment, motivation and aspirations, as well as what I propose calling “disciplinary emotions” such as pride and fear, confidence and insecurity, feelings of disciplinary superiority and inferiority. Disciplinary emotions do not seem to have attracted systematic attention, but they are important for understanding interdisciplinary relations, as can be revealed by simple exercises of pair wise comparisons between, say, economics and sociology, and then between economics and neuroscience.

Discipline 3: dimensions
In considering how disciplines relate to one another as in intrdisciplinarity, it is important to distinguish between two dimensions of disciplinarity. The first is Internal: the degree of a discipline’s internal coordination, integration, coherence, unity. Disciplines vary remarkably along this dimension (compare economics to psychology, for example, the first having been much more unified than the latter). The second is External: the degree of a discipline’s isolation or separation from other disciplines (consider economics and human geography for an illustration: the latter’s identity is dependent on ongoing importation of ideas from other disciplines, while economics is far more self-contained).
‘Absolute Discipline’ helps see matters of degree and contingency
Given the above two dimensions, we can then imagine the fiction of ‘Absolute Discipline’: it is one that enjoys complete internal coherence and unification combined with complete external separation from other disciplines. An Absolute Discipline is an extreme case that does not exist in the actual world. Yet it is a helpful fiction in that it helps remind us of the fact that real-science disciplinarity and interdisciplinarity come in degrees: nothing is completely isolated and unified, and nothing is completely open and scattered. Real-science disciplines are more-or-less so, in varying degrees. These degrees vary between disciplines and across the historical development of each of them.

Indeed, the fiction helps keep in mind that the forces and principles that shape disciplines and their relations are not uniform throughout the disciplinary landscape. What keeps disciplines (internally) together and (externally) separate from each other – to the extent it does - is discipline-specific and context-specific. Whether it is a structure of higher education, a set of practical pressures, a set of intellectual achievements and aspirations, an academic power structure, or whatever combination of these and other things, varies from case to case.

The unit issue
The above observations also help to see that it is far from evident that the discipline is a natural unit of focus when considering external relations. Taking the discipline as the unit entails dealing with interdisciplinary relations, that is, literally relations between disciplines. But obviously this unit is in many cases too large. Among other things, this is because disciplines are not perfectly integrated and uniform internally, as noted above. In most situations it is not disciplines as wholes but rather some smaller units that are brought in contact with one another. Taking the unit to be the research field suggests focusing on interfield relations. Taking the unit to be something still smaller, such as the theory in isolation from practices and cultures of inquiry will entail a focus on intertheoretic relations. The choice of the appropriate unit is contingent, depending on the peculiar features of the particular context: sometimes disciplines, at other times fields
or sub-fields, then theories or models. In what follows I continue to put ideas mostly in
terms of discipline. I am aware that revisions may (or may not) be needed when replacing
discipline by field or theory; more detailed and more empirical investigation will tell
whether revisions are needed.

Further complexities are due to the presence of rival schools of inquiry within disciplines
and research fields, driven by different convictions about the appropriate theories and
research techniques and worldviews. In extreme cases, the disciplinary identity of a
school – its being a legitimate part of a discipline - may become questioned. The relations
between environmental economics and ecological economics illustrate.

**Interdisciplinarity: Ideologies**

A striking facet of the variety of forms and ideas that characterises interdisciplinarity is
that it is justified, celebrated, and promoted on the basis of very different ideologies of
inquiry. I can recognize at least three such distinct ideologies:

*The ideology of intellectual unity*: This is based on the desire for comprehensive and
unified worldviews. The slogan is: the world is one, so science should be one as well.

*The ideology of creativity and novelty*: This is an expression of the desire for innovative
inquiry, undisciplined by rigid disciplinary boundaries and dictates.

*The ideology of practical relevance*: This is characterised by the desire for practically
useful, flexible and open research, unbound by rigid academic structures and inward
looking conventions, willing to serve external interests.

This last one can be further divided into different kinds based on different practical
values or interests. This is naturally very important given the variety and contestability of
ways in which something can be practically relevant or useful. The call for ‘people’s
science’ does not coincide with the demand for research serving short-term business
interests, for example. The student movement of the 1960s and the agents of the
commercial pressures of the first decade of the 21st century both speak highly of interdisciplinarity but do not share an ideology of it.

**Interdisciplinarity: Agents**

Related to the above remark on the variety ideologies of interdisciplinarity, we can identify some characteristic agents that drive and promote it. There are agents that operate *from outside* the research activity itself. These include *Academic Bureaucrats* who may pursue interests that conflict with those of disciplinary authorities. Indeed, interdisciplinarity is a way of weakening the academic powers of disciplinary authorities (Moran 2006). Another set of external agents are those that impose *Extra-academic demand* for practical problem-solving capacity. Practical problems suggest research problems that may not otherwise find their way onto the agenda of research, as well as problem-solving strategies that would not be otherwise followed in research. This contrasts with autonomously set research tasks and strategies of inquiry.

There are also agents that operate *from within* disciplinary activity itself. Without trying to be exhaustive, I want to point out two kinds of agents that derive their goals from opposite perceptions about the situation in their discipline. One class consists of the agents of *Disciplinary dissent*, those critical of the contents of the mainstream of the discipline. They seek to connect with allies in neighbouring disciplines so as to weaken the mainstream or orthodox position in their own discipline. Examples of such *heterodox interdisciplinarity* include parts of neuroeconomics and institutional economics. The other, opposing agency derives from *Disciplinary orthodoxy*. In this case, the agents of the mainstream position seek to apply or transfer its contents to other domains or disciplines. This gives rise to *orthodox interdisciplinarity*, sometimes called academic imperialism, with economics imperialism serving as a prime example. More on this later.

**Clashing forces**

By now it must have become obvious that the ideologies and agents of interdisciplinarity do not all pull in the same direction. They may clash with one another, and they tend to clash with disciplinary powers as well. The outcomes of these conflicting and interacting
forces are not easily determinable. The trajectories of their emergence must be traced empirically, type by type, case by case. And there is no single overall normative judgement available for all kinds and instances of interdisciplinarity. This is not to deny that there are similarities between the cases, but multiplicity is the dominant theme.

Given the multiplicity of ideologies and agents of interdisciplinarity, it is not surprising that interdisciplinarity itself comes in a variety of kinds. The identification and characterisation of these kinds is a major task for the inquiry into interdisciplinarity. Even though much has been written on kinds of interdisciplinarity, there seems to be demand for fresh rethinking.

**Kinds of Interdisciplinarity**

**Interdisciplinarity: Dimensions of taxonomy**

The very idea of classifying kinds of interdisciplinarity is based on the presupposition that even though particular cases of interdisciplinary relation are strictly speaking unique, there are relevant similarities among them such that they can be grouped in taxa. A number of taxonomies have been suggested to distinguish between various ways in which disciplines may get in contact with one another. It seems these suggestions typically lack a systematic and explicit idea of the dimensions on which the taxonomies are built. Here is an attempt to propose the beginnings of such an idea.

The first dimension is the flexibility or fixity of the *identity* of participant disciplines: will a participant discipline retain its disciplinary identity (as the discipline it is) or will it undergo change? The second dimension is the flexibility or fixity of the *contents* of participant disciplines. By ‘contents’ I mean the theoretical resources characteristic of a discipline. The fixity of contents permits changes in research questions and in the empirical information produced by research exploiting those resources. On the other hand, change in contents is compatible with fixity of identity. (The identity/content distinction is not sharp and stable. “Large enough” change in contents will induce a change in identity.) The third dimension is given by the types of *interrelations* between...
the participant disciplines. This is a heterogeneous bunch of possible relations, such as Additive / Inspirational / Supportive / Critical / Collaborative / Imperial / Colonial / Integrative / Dismissive.

Based on such dimensions, a stipulative taxonomy emerges. It bears similarities with what others have suggested earlier, but it attempts to be more precise about the characterisation of the contents of the types of interdisciplinarity. Yet it is obvious that we are not yet even close to a comprehensive typology. Insofar as the vocabulary is concerned, I use existing terminology (sometimes with established meanings, sometimes with revised meanings), but I also suggest some new terminology that I need for expressing new ideas.

Note the terminological convention on which *inter-disciplinarity* (with hyphen) appears as a special version of *interdisciplinarity* (without one) that serves as the general umbrella term that encompasses many kinds.

**A Multi-disciplinarity**

This is the weakest way in which disciplines may connect. In multi-disciplinarity, *the disciplinary identities and contents of the participant disciplines remain unchanged*. The tension that drives multi-disciplinarity is between the simplicity of disciplinary perspectives and the complexity of the phenomena or problems addressed. Any single separate disciplinary point of view will be too narrow to highlight the complexity and richness of the phenomena or problems of interest. Therefore, contributions are needed by several disciplines, and their combinations are based on the division of intellectual labour: you do that part, I do this, etc. Separate contributions are added up without interaction or interpenetration or integration between the participant disciplines. Examples include European Studies (ranging from history and linguistics to economics and literary studies); research on climate change (from geology and chemistry to economics, law, and cultural studies); and economic policy advice (which should be at least multi-disciplinary at least in principle - while in practice exogenous variables not dealt with by economics are often left at the mercy of dilettante intuition).
B Inter-disciplinarity
This is a version (with a hyphen) of interdisciplinarity that is defined in terms of interaction between disciplines. Interaction is allowed to have consequences for their contents, but not for their identities. *The participant disciplines retain their identities, but their contents undergo changes in consequence of the interactions.* Interactions are of various kinds, and so are the resulting changes.

*Borrowing* is a major category of interaction, including inspiration, metaphor transfer, incorporation of elements in new theoretical or methodological contexts (eg the employment by social sciences of evolutionary metaphors from biology).

*Support* is another form of interaction whereby confirmation may flow from one discipline to another; for example, a premise of discipline A may be backed up by the research results of discipline B.

*Criticism* is the reverse flow of argument by way of which tensions between disciplines may sought to be settled; for example, a premise of discipline A is charged for being inconsistent with results of B (eg traditional ‘economic man’ is currently under the pressure coming from experimental psychology and neuroscience).

C Cross-disciplinarity
This goes a step or two further in connecting disciplines by the activity of crossing. What happens is *crossing disciplinary boundaries*, interpenetration of participant disciplines, entering neighbouring domains. These crossings will have consequences for *both the contents and the identity* of at least one participant discipline. Cross-disciplinarity comes in various forms.

*Egalitarian integration* takes place when the contents of disciplines A an B are fused such that major parts of both are integrated with one another.
*Academic imperialism* is not similarly symmetric or egalitarian: what happens is that the contents of A are replaced or overridden by those of B. Economics imperialism – economic concepts, models, and methods being increasingly used in political science, law, ecology, and elsewhere – will be cited by many as the prime example of this sort of cross-disciplinarity. Qualifications will follow in a moment.

*Academic colonialism* is a weaker version of imperialism: academic colonies drawing on the contents of discipline B are established inside another discipline A. The very idea of an intellectual colony suggests a unit smaller than whole disciplines. Colonies are akin to fields or schools. Examples include rational choice sociology (a colony inside sociology, drawing on economics) and behavioural economics (a colony inside economics drawing on cognitive science).

**D Trans-disciplinarity**

The key activity here is that of *transcending*. Trans-disciplinarity transcends old disciplines and their boundaries and establishes *a distinct forum for new theory and inquiry, communication and coordination*. There are two major versions, the extra-academic and the intra-academic.

In *extra-academic trans-disciplinarity*, academic and non-academic perspectives are fused in order to solve practical problems that derive from those extra-academic points of view. The context of practical application plays a major role in shaping the research agenda and in setting the standards of relevance in research.

In *intra-academic trans-disciplinarity* the research agenda and standards are primarily shaped by intra-academic aspirations. It may be a *broad* project of developing a disciplinally homeless novel theory that serves to unify several of old theories in various fields in terms of a common framework (eg complexity theory). Or it may be a *narrow* project of filling in an unoccupied niche between established disciplines by inventing a new research field or theory involving a novel agenda and novel research strategies. Indeed, the conventional perceptions notwithstanding, the scale of trans-disciplinary
activity may range from very small – such as when a new tiny specialty is created to occupy a gap between old disciplines or fields of research – or very large – such as when developing a new field of broad scope (cf cognitive science, behavioural science).

**E Post-disciplinarity**

This is a kind of anti-disciplinarity that is disrespectful for any disciplinary conventions, boundaries, constraints, and pursuits. Post-disciplinarity activity exploits whatever intellectual resources are available, wherever – provided they serve a purpose, whatever its origins in the practical and intellectual realms. Post-disciplinarity manifests a dream of regaining pre-disciplinary liberties.

**Behavioural economics**

As an illustration of some of the types of interdisciplinarity above, the developments of behavioural economics are helpful. Behavioural economics seems to have developed through a few stages. At *stage 1*, it exhibited *critical inter-disciplinarity*. Experimental psychology and fragmented psychological theorising were invoked to put the behavioural assumptions of conventional economic theory in question. At *stage 2*, it exhibited *colonial cross-disciplinarity* whereby behavioural economics was established as a field of inquiry within economics – as a colony of psychology and neuroscience, as it were. At *stage 3*, behavioural economics seems to be playing a role as a participant in *unificationist trans-disciplinarity* whereby a general behavioural basis for the social sciences is being developed, based broadly on the contributions of a variety of fields and disciplines, such as evolutionary theory and cognitive science (cf Gintis 2007). Rather than consecutive stages, these three could also be viewed as three partly parallel functions.

**Intellectual imperialism 1**

I have mentioned academic or intellectual imperialism as a form of cross-disciplinarity, and will now add a couple of further observations. The first is to suggest a distinction between two kinds (Mäki 2007; Mäki&Marchionni 2007). When practicing *domain-only imperialism* one seeks to unify phenomena in domains of disciplines A (such as
economics) and B (such as political science) in terms of theory in A (such as that of rational choice in a market). This can be dismissive of the contents of B, and may have no consequences for the standards and practices in B. Discipline A does not intrude into the practices of discipline B, but only sets out to apply theories an methods in A to explain phenomena that used to belong to the domain of B. In contrast, in disciplinary imperialism such intrusion does take place as one seeks to transform the standards and practices of B in line with those of A. The social mechanisms by which these two kinds function as well as their consequences may be very different.

**Intellectual imperialism 2**

There is a terminological puzzle that suggests itself as a challenge for interdisciplinary studies. There are many processes in various corners of academic life that could be characterised in terms of the above two kinds of imperialism – but the term ‘imperialism’ itself is seldom used. However, it is customarily used of “economics imperialism” by proponents and opponents alike. They employ the term to denote the application of economic ideas (such as rationality and market, cost and benefit, investment and return, efficiency and equilibrium, etc) in domains and disciplines such as sociology, political science, anthropology, law, human geography (modelling individual rational choice and interaction in markets for marriage and divorce, crime and punishment, law and politics, health and illness, etc).

The puzzle is this: why are the following phrases not in wide use even though in all cases what happens is a pursuit of broadening the epistemic reach or cognitive control of the theories and methods of a research field across disciplinary boundaries? Evolutionary imperialism? Cognitive science imperialism? Computational imperialism? Network imperialism? Cultural studies imperialism? Social constructivist imperialism? So, why not?

My hunch is that in looking for answers to the question, we may have to invoke ideas of relative disciplinary strength, the details of the trajectory of disciplinary formation, and what I earlier called disciplinary emotions. An established powerful discipline arrogantly
taking over weaker neighbouring territories (the case of economics) tends to be named differently from freshly emerging trans-disciplinary formations driven by youthful enthusiasm or oppositional spirits (computation, cultural studies).

**Kinds of progress via interdisciplinarity**

**Concept of progress**
It is time to move on to the normative plane and start thinking of the standards on which to judge variants of interdisciplinarity. As I said in the beginning, the concept of progress suggests itself as a natural candidate for these purposes. The concept is already in active use in the debates around interdisciplinarity, and the capacity of making progress is generally considered a major virtue of scientific work. The concept of progress is a *process concept* and a *normative concept*. Talking about progress requires fixing a norm or goal with respect to which a process is progressive: it makes or facilitates improvements in getting closer to meeting the norm of attaining the goal (Mäki 2002).

**Species of progress**
A very simple distinction between epistemic and non-epistemic sorts of progress will be helpful for our purposes. *Epistemic progress* is progress in terms of knowledge, truth, explanation, prediction, confirmation, disconfirmation: these are forms of advancement of learning about the world and our theories about it. *Non-epistemic progress* divides into [a] progress of facilitators of epistemic progress such as questions (erotetic progress) and institutions (institutional progress); and [b] progress in reaching practical goals such as problem-solving and control. The rest of the paper will list types of progress potentially made through interdisciplinarity in somewhat more detail.

**Invention and adoption**
The characteristic virtue of interdisciplinarity is its presumed capacity for cross-fertilisation by inspiration, association, borrowing, and metaphor transfer. This may result in the invention or adoption of novel and hopefully better concepts, hypotheses, theories, methods (eg evolutionary economics). One may manage to invent entirely novel ideas, or
just adopt ideas from an old context and introduce them in a new context and thereby generate novelty.

**Revision and error elimination**

Interdisciplinary encounters may also become matters of confrontation, prompting revision in the contents of at least one participant discipline (think of economics being confronted with experimental psychology and neurobiology). This may be viewed as *error elimination*, and it may take on the more moderate form of *reform* (e.g., add variables to utility function) or the more radical form of *rejection* (e.g., drop constrained optimization). The background presupposition in such moves is an appreciation for coherence between disciplines and research fields.

**Coherence and confirmation**

Coherence works for confirmation, too. Interdisciplinary encounters provide opportunities for enhancing coherence between disciplines. A premise of (a theory in) one discipline is often a conclusion of another, and one may wish to align the two so as to remove any possible conflict between them. Increased theoretical coherence of this sort manifests progress because it is a source of *increased confirmation*. This is not confirmation by direct empirical testing, but rather indirect confirmation by being embedded in a broad web of theories across disciplines.

**Scope expansion**

The scope of a theory in one discipline may expand as it is being used for explaining phenomena that traditionally were considered belonging to the domain of another discipline. This sort of expansionist (or imperialist) explanatory unification is another way in which *growth in confirmation via coherence* may take place. The idea is that our assurance of the correctness of a theory will grow as the theory successfully explains an expanding domain of phenomena. Whether this is also taken to be a matter of progress in explanation itself depends on one’s account of how explanation and unification are related. My view is that the connection between the two is too weak to support attributing explanatory progress to these cases. (Mäki 2000)
Ontological unification
Yet cross-disciplinary explanatory unification (even of an imperialist type) may serve as a valuable source of new information about similarities between what previously appeared different. This is a classic scientific achievement that requires the unification to be a matter of discovery about some real unity in the world: therefore ontological unification must take place. Newton was celebrated for such a cross-disciplinary achievement of ontologically unifying falling apples, trajectories of cannon balls, and the movements of celestial bodies. Today, the question is whether Gary Becker should be praised similarly for having established substantial similarities between buying stocks, hiring labour, getting married, serial killing, getting addicted to a drug. (Mäki 2000, 2007)

Opening black boxes
Each discipline accommodates numerous black boxes in its theories and models: input phenomena and output phenomena are revealed to be regularly connected, but the details of the connection between them remains hidden in the box. What may be called causal penetration amounts to opening those black boxes and revealing a mechanism inside. In principle, this gives deeper and better-confirmed explanations. Now often the contents of such boxes belong to the domain of another discipline or field. Opening the box may take on one of the two forms of procedure:
[a] Ask help from your neighbour. Another discipline is called for to contribute its special expertise to the identification and description of the contents of the box. This strategy is exemplified by the current negotiations around the role of neurobiology in opening the black box of the human mind for the social sciences.
[b] Rely on your own devices. This may be a matter of another imperialist expansion: the discipline in question itself takes it as its task to provide an account of the contents of the box by reapplying its own theories to this new domain. This is exemplified by the use of economic theory itself in opening the former black boxes of the government and the family: politicians and bureaucrats as well as family members are portrayed as rational choosers in new kinds of market.
Learning about disciplinary domain
Interdisciplinary encounters often help develop *sharper conceptions of the appropriate domain of discipline*: The domains of two disciplines may overlap, but they also at least partly exclude one another. Sometimes there prevails great confusion as to what precisely is the domain of a given discipline. The current situation in economics provides an extreme case. In its encounters with political science, sociology, law, and other social science disciplines, some economists consider all human action to belong to the domain of economics, provided action responds to incentives and the situations are characterised by scarcity. On this view, economics becomes the universal social science. On the other hand, in its encounters with experimental psychology and neurobiology, some economists have adopted the old Paretian line of circumscribing the domain of economics very narrowly to only include action that is frequently repeated so that agent learning will have a chance to proceed to completion. On this conception, the domain of economics becomes very small indeed, and it should retreat from much of its pre-imperialist territories as well. Economics appears to be facing exciting tensions due to its interdisciplinary encounters.

Erotetic progress
This is *progress in questions*, and here we are talking about facilitators of epistemic progress rather than progress in knowledge about the world directly. Erotetic progress is often strongly enhanced by interdisciplinary encounters. Progress takes on two forms:
[1] *New* questions may emerge. The range of questions that can be asked is constrained by a discipline and is broadened by going beyond its boundaries.
[2] Questions can be made *sharper*. Interdisciplinary comparisons help see what exactly is being asked and what can be answered, and thereby old vague questions can be replaced by more carefully formulated questions.

Once new questions and sharper questions become answered, there will be advancement in learning about the world. Questions are great facilitators of epistemic progress, and interdisciplinary encounters are great facilitators of erotetic progress.
Methodological progress

This is progress in standards and techniques, another sort of progress in the facilitators of epistemic progress. Here we are taken back to the early remarks above on the conventional images of disciplinarity (rigor, high standards, competence) and interdisciplinarity (vague, sloppy, dilettante). Indeed, according to those conventional images, disciplining is supposed to be a major function of disciplines! So how can interdisciplinarity possibly promote methodological progress? One answer is cross-disciplinary imperialism whereby the standards of an allegedly superior discipline (such as economics) are imposed upon a supposedly inferior discipline (such as sociology). Another, less straightforward, possibility is making methodological progress through interactive learning by way of imitation, competition, and criticism across disciplinary boundaries.

Practical progress

We then come to the form of non-epistemic progress that drives much of (the rhetoric on) interdisciplinarity. This is improved capacity of practical problem-solving and control, ranging from ‘people’s science’ to commercialised research. Now it is evident that this is an extremely mixed category of progress for the simple reason that there is a vast variety of kinds of practical problem and practical relevance. No single measure of gauging practical progress can possibly be conceived. Indeed, in judging practical progress, one cannot escape invoking criteria of importance of non-epistemic values. Such values can be used for measuring the significance of the problems to which solutions are sought. No generic and neutral standard of ‘practical relevance’ will do, some misguided administrative declarations notwithstanding. Consider climate change. It might seem to be in almost everybody’s (future generations included) best uncompromised interests (perhaps in some cases against their own recognition) to find solutions to the related problems via interdisciplinary research. Then consider medical inquiry and the marketing of new medicals by making up needs, by constructing and imposing ‘health problems’ – this seems to be in a different class of ‘practical problems’ and ‘practical relevance’ defined in terms of values that can be easily contested.
Institutional progress

This consists in improving the institutional facilitators of epistemic progress. The institutional framework of disciplinarity and interdisciplinarity comprises funding structures, organisational structures, incentive and reward structures, relations of collaboration and competition, standards of quality and publishability, structures of intellectual authority and academic power, conventions of communication, mechanisms of setting research agendas, etc. Institutional progress requires redesigning (breaking, weakening, strengthening, rebuilding) disciplinary structures. This may be well intended to promote epistemic progress and/or practical progress. However, by way of unintended consequence, one may also risk enhancing the corrosion of the standards of scientific quality and/or the subjection of scientific research to unwanted external extra-scientific interests.