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Variably Self-Organized Interactors with Relatively Stable Instruction Bases: How to Generalize Darwinism for Fruitful Socioeconomic Applications

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Abstract: In search of general principles of Darwinism with fruitful socioeconomic applications, this paper introduces the notion of variably self-organized interactors with relatively stable instruction bases – of which organisms with their genomes, and socioeconomic organizations with their institutions ("rules-of-the-game") are special cases. Socioeconomic evolution then falls into self-organizing ("spontaneous ordering") instructed by actual institutions, formally corresponding to ontogeny; and changes of institutions, corresponding to phylogeny. While the two are interwoven more closely than their biological counterparts, their separation is logically clear and fruitful. It helps to clarify several aspects of socioeconomic evolution, including developmental differences and possibilities of deliberate reforms.

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1 Introduction

More and more economists and other social scientists are recognizing that it does not suffice to study economies and societies as fixed mechanisms, consisting of fixed parts of fixed behaviors interconnected in fixed ways, which only function, but that for many important questions it is necessary to recognize that they are in fact variable entities that not only function, but may moreover change parts, while these may change their behaviors and interconnections, and thus organize, reorganize, develop and evolve.[1]

In search of understanding of such entities, virtually all of these enlightened social scientists agree that much can be learnt from biology. The reason is that biologists – be it because of their higher wisdom or because of the more pressing nature of their subject matter – recognized that organisms must be treated as variably organized, developing and evolving entities longtime ago, and are therefore much more advanced in this search than social scientists, among whom modeling of economies and societies as fixed mechanisms is still widespread. But there is a fundamental question on which even these enlightened social scientists still disagree: which parts of what biologists have learnt about organisms may also be relevant to socioeconomic organizations, and thus helpful, and which parts are on the contrary so biology-specific that trying to learn from them would be fruitless and possibly misleading?

Perhaps the most fundamental disagreement concerns the relationship between Darwinism and socioeconomic evolution. There appear to be two main competing views: General Darwinism (GD), perhaps most forcefully advocated by Hodgson (2002), Knudsen (2004), and Hodgson and Knudsen (2006); and Continuity Hypothesis (CH), whose main proponents are Witt (2003, 2004) and Cordes (2006, 2007). The main idea of GD is that the Darwinian theory explaining biological evolution can suitably be generalized and in the generalized form also explain socioeconomic evolution. In contrast, CH considers Darwinism only useful for explaining the evolutionary origins of the human cognitive abilities with which socioeconomic evolution starts and on which it builds, but in its own specific ways that have little to do with the ways of biological evolution.

This paper proposes a synthesis of modified versions of both GD and CH, finding GD in need of more extensive modifications than CH. The latter is only qualified in its negativism about applications of Darwinian principles to socioeconomic evolution, but much of this negativism is at the same time justified for large parts of the Hodgson-Knudsen version

[1] That this is necessary to admit in policy analysis, in order to avoid, and not recommend, policies with harmful unintended effects, is extensively argued in Pelikan (2003a).

of GD (HK-GD), which is found not general enough. In other words, the paper agrees with Witt and Cordes that socioeconomic evolution builds on outcomes of biological evolution, and may thus be understood as its continuation, and with Hodgson and Knudsen that this continuation may be understood as sharing with the biological evolution, and thus repeating, certain general principles of Darwinism – but with the qualification that these principles are somewhat different from those of HK-GD.

As considered in more detail below, what makes HK-GD insufficiently general is that it retains from biological Darwinism certain notions that are too biology-specific, and therefore lack clear socioeconomic counterparts. In the first place, these are all the notions related to *inter-generational* replicating, in particular "inheritance" and the labeling of genes as "replicators." The crucial point that HK-GD overlooks is that organisms and socioeconomic organizations substantially differ in the ways in which they can evolve and preserve the key information about the evolved features over time. For organisms, because of the relative fragility of biochemical memories, this information needs to be periodically renewed and corrected, for which series of generations, where replicating and inheritance are indeed central, appear to be the only feasible way. In contrast, as socioeconomic organizations may use memories of another nature, they only rarely have offspring, but most often last, evolve or dissolve as childless singles.

In search of the principles of Darwinism that can be seen at work in both biological and socioeconomic evolutions, this paper proposes another, more general version of GD, named "Sufficiently General Darwinism" (SGD), with two purposes: to demonstrate that such principles do exist and are theoretically interesting, and to indicate how they may help to clarify some of the still poorly understood aspects of socioeconomic evolution, including developmental differences and the possibilities of deliberate reforms. How much SGD will be able to help with these clarifications is suggested as a criterion for judging its usefulness both absolutely and in comparison with HK-GD.

SGD and HK-GD mainly differ in the relative importance they ascribe to the different roles of genes. To be precise, following some recent developments in molecular biology, SGD also differs in extending attention from genes to genomes, as these have been found often to contain, in addition to the genes that instruct the synthesis of proteins, other important segments of DNA – in particular those that instruct the synthesis of key RNA-regulators (Mattick, 2004). But this extension is only secondary. Be it genes or genomes, the main difference is that SGD ascribes less importance to their replicating and more to their instructing. In consequence, to generalize the genotype-phenotype distinction, it uses the couple "instructor-interactor," instead of "replicator-interactor." It is indeed for genomes as instruction bases for the forming and functioning of organisms, rather than as replicators copied from one generation of organisms to the next, that logically consistent and empirically meaningful socioeconomic counterparts will be possible to identify.

But replicating will not be neglected. SGD pays due attention to all the different roles that genomes may be seen to play: *replicating*, as emphasized by Dawkins (1976), who is perhaps also the first to call them "replicators"; *evolving*, as emphasized by Hull (1980), who correspondingly calls them "evolvers," and *instructing*, which is only gradually being brought to light by molecular biologists and still largely neglected by social scientists. But it is precisely for making Darwinism sufficiently general for their purposes that they must pay more attention to the instructing than to the replicating. Only one kind of replicating can be seen to have a meaningful socioeconomic counterpart – namely the *intra-organism* one, by which the genomic instructions of one multicellular organism spread to all of its cells, and which may be seen to correspond to what CH calls "imitation," "diffusion," or "transmission," understood as taking place among the members of one society.

Of course, social scientists cannot be accused of ignoring the instructing role entirely; for instance, "genes-as-instructors" are mentioned already in Hodgson (1993). It is only that after mentioning it, they have not said much more about it. One reason may be that it requires more knowledge of recent molecular biology than what appears to be common among social scientists, even the evolutionary ones. Another reason may be that recognizing the great importance of genomic instructing was for a long time considered politically incorrect: ideological pressures made it nearly obligatory to profess that for the forming and functioning of organisms, their environments are much more important than their genomes.

The obstacle of political correctness is here left aside as no longer belonging (if it ever did belong) to serious scientific research. Concerning the knowledge obstacle, the following section will try to help interested readers to overcome it by summarizing the basic facts of molecular biology that SGD may be seen, with the help of basic principles of information processing, to generalize, while also noting the main differences between SGD and HK-GD in how these facts and principles are taken into account and understood.

But that section is only optional, for no knowledge of biology will later be necessary. SGD will be built as an abstract conceptual framework, independently of any of its possible biological and socioeconomic applications, around the general notions of variably self-organized interactors with relatively stable instruction bases – of which organisms with their genomes, and socioeconomic organizations with their institutions ("rules-of-the-game") will only later be found to be special and in many respects different cases. These notions will allow general evolutionary processes to be decomposed into two (possibly overlapping) layers: the self-organizing ("spontaneous ordering") of interactors according to their existing instruction bases, and changes of these bases – referred to as "general ontogeny" and "general phylogeny," respectively. SGD puts all this on solid micro-foundations by clearly identifying for each interactor the set of its constituent agents, through which the instructing must act and on whose intrinsic abilities this acting critically depends.

To avoid misunderstanding and misdirected criticism, two early disclaimers may help. First, despite the great importance ascribed to the instructing role of genomes, SGD has nothing to do with naive genetical determinism. It does not claim that instruction bases alone fully determine the forming and the functioning of their interactors, but recognizes that environments may also play important roles. It only makes it clear that however important these roles might be, they depend on, and are ultimately constrained by, the instruction bases. SGD is thus in a sense deterministic, but not naively and only negatively: it recognizes that instruction bases may be far from determining what specific features their interactors will develop, but affirms that they always determine what features their interactors cannot, even in the most ideal environments, acquire.

Second, despite specifying for each interactor the set of its constituent agents, SGD is not naively reductionist. It does not see an interactor as a "simple sum" of its agents – as does the naive kind of reductionism that holists are so fond of criticizing, and that in fact appears to be invented by them as an easy-to-beat straw man – but fully recognizes that what an interactor is and does depends on both its agents and their organization. SGD also recognizes that there may be important feedback relationships through which the organization may influence and condition properties of its agents. SGD only makes it clear that nothing can fall as a holistic mystery from the sky, but all must stem from constituent agents: at least some of them must first form the organization before this may start influencing them.

The paper is organized as follows. After the optional Section 2, with its survey of basic biological facts for interested readers, the task of the following four sections is orderly to build SGD as an abstract conceptual framework. Section 3 assumes a set of agents that, with more or less extensive help of inputs from environments, self-organize into, and function within, an interactor, which they consequently endow with a certain form and a certain function (behavior). For a clear micro-view of how an intreractor may acquire both its form and function, agents' behaviors are divided into two (possibly overlapping) dimensions – associative and operational.

Section 4 introduces the notions of "instruction" and "instructing" and elaborates the view that all behaviors, of both agents and interactors, must be instruction-based – thus generalizing the increasingly recognized fact that all human mental processes, including economic decisionmaking, must in a certain sense be program-based.[2] It distinguishes three sources of an agent's actual instructing – initial, external, and own learning – and identifies the initial instructing as the seed without which the actual instructing could not develop, either by external instructing or by own learning, and by which this development is ultimately constrained.

Section 5 considers the different success criteria that both agents and interactors may be internally striving and/or externally required to meet, and introduces the notion of "instruction base" to refer to the additional instructing, formally ascribed to an interactor, that its agents may need to make it, in terms of given criteria, successful. It then specifies general ontogeny as the processes during which agents obeying given instruction bases form and develop corresponding interactors; and general phylogeny as the trial-and-error searches for the instruction bases of successful interactors, during which these bases themselves form, change, and evolve. It is such searches that are "Darwinian" in the sufficiently general sense that has consistent and meaningful interpretations in both biological and socioeconomic evolutions.

Section 6 completes the building of SGD by following Simon's (1969) view of the architecture of complexity and considering that agents-interactors that form multilevel hierarchies. For such a hierarchy, it establishes a corresponding hierarchy of instruction bases, and clarifies how the two relate to each other. It shows that they do not mix, as the latter consists of pieces of information and the former of more "material" bodies that form and function; and that the two need not have the same number of levels, as instruction bases of one level may suffice for the forming of successful agents-interactors of several levels.

The task of last three sections is to apply SGD to socioeconomic evolution. Section 7 shows why, logically, the instruction bases of socioeconomic interactors, including entire economies and societies, are institutions in the sense of "rules-constraints" or "rules-of-the-game" – as defined in institutional economics by North (1990) and advocated for uses in evolutionary economics by Pelikan (1992, 2003c) – rather than both the more narrowly defined "routines" (Nelson and Winter, 1982) and the more broadly defined "memes" (Dawkins, 1976, 1982).

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[2] For particularly clear and convincing expositions of this view, see Holland (1995), Cosmides and Tooby (1997), and Vanberg (2004).

Section 8 notes that this increases the importance of (new) institutional economics, but also imposes on it new tasks – in particular, to define "institutions" as a clearly structured multilevel notion, and to study them not only for their effects on transaction costs and other incentives, but also as factors that both instruct, and are produced by, socioeconomic evolution. This section also clarifies the socioeconomic versions of ontogeny and phylogeny, with emphasis on the differences from their biological counterparts – in particular their much closer time scales, and the absence of the Weismann barrier, which allows – in agreement with Nelson and Winter (1982), but in disagreement with Hodgson and Knudsen (2006) – some "Lamarckian" feedback from the former to the latter.

Admitting that not all social scientists may find SGD helpful, Section 9 concludes by considering four longstanding socioeconomic issues for which its usefulness appears most likely to be recognized: group selection, economic development, reform policies, and multiculturalism. But it cannot be the task of this paper to provide any of these issues with a definite answer. How SGD may help to deal with them will only be outlined, to illustrate the breadth of its potential usefulness, and hopefully also give ideas to readers on how to use it in their own studies.

2 Ten basic biological facts for interested social scientists

To recall, this section is optional, reserved to the readers who are themselves interested in learning from biology. It surveys the basic biological facts by which the building of SGD has been most inspired, and which it is intended to comprehend if applied back to biology.[3]

The survey is divided into ten basic biological facts (BBFs). Leaving aside the relatively simple and for social scientists least interesting bacteria, seven facts concern multicellular organisms (MOs), and three concern those MOs that are moreover social (MSOs). These have been particularly inspiring, as they most tangibly illustrate the logic of multilevel organizing, an important key to understanding socioeconomic evolution. Of course, most of these facts are so well-known that surveying them is more a matter of record than new information for readers interested in biology . It is only the view of their possible relevance to socioeconomic problems that will partly be novel: some will be found more relevant, and others less, than usual.

BBF1. Each MO possesses a specific genome of its own – a message coded in the

[3] Trying to learn as much as possible directly from contemporary biology, I mainly drew on Alberts et al. (1998), Camazine et al. (2001), Mattick (2004), Carrol (2005), and Barrick and Breaker (2007), and was greatly helped by extensive consultations with René Doursat, working on self-organization in biology and bio-inspired systems, and Andrea Pelikan, specialized in biotechnology.

four-letter alphabet of DNA, containing genes, but not only genes – of which virtually each of its cells contains a full copy. If the cells specialize in different functions (as they usually do), each of them employs only those parts of the genome that correspond to its specialization, while blocking (ignoring) the rest.

BBF2. An MO is variable in both its form and its behavior: its cells may be multiplying, developing or dying, and they may be establishing, modifying or interrupting their interconnections. In contrast, it must strive to keep its genome stable as the great constant of its life; failing to do so results in cancer or other disorders. In this context, in is instructive to realize that even the so highly developable and flexible human brain reposes on a highly rigid genomic message, and that this message must in some sense be crucial, for other species with other genomic messages, if they have brains at all, these are substantially less developable and flexible.

BBF3. The genome plays four roles: (A) instructing the forming and the functioning of its actual MO; (B) spreading its message to the entire MO by replicating internally across the cells of this MO; (C) preserving its message over time by replicating to a new generation of MOs (offspring), often by recombining its segments with segments of another genome; and (D) evolving, mostly during (C), by modifying its message as a result of recombinations of its segments and/or of various copying errors (mutations) caused by unrelated ("random") disturbances. Roles (B) and (C) are played by the entire genome, role (D) may involve any of its parts, but role (A), the instructing, is played only by some of its parts, while the rest is often called "junk."[4]

BBF4. Ontogeny, in which the genome plays roles (A) and (B), is the complex of processes that build for the genome its actual organism, beginning with what is often considered separately as "embryogeny," and often passing through several development stages, during which the organism importantly changes both its form and function. These processes can be seen as multilevel chemical reactions, of which only the first level – the synthesis of specifically tailored proteins and RNA-organizers – is genomically instructed. The rest then spontaneously unfolds upwards, as a multilevel hierarchy of self-organizing, of which the specific proteins and RNA-organizers are the first-level agents. It is through the

[4] That not all parts of the genome play the instructing role is now established, but which parts do play it is not yet fully known: many of those that were at first considered "junk" were later discovered to have important instructing functions – and such discoveries continue. For a long time, it was believed that the only instructing parts were genes – the segments of DNA that instruct, by means of their RNA-transcripts, the synthesis of specific proteins, which are the basic agents of both the organizing and the functioning of each cell, and consequently of the entire organism. But it is now known that important instructing is also performed by certain segments of DNA whose RNA-transcripts do not concern proteins, but become active organizers ("ribo-switches") themselves (Mattick, 2004, and Barrick and Breaker, 2007)..

specific tailoring of these agents, with its ascending specific consequences for all the higher self-organizing levels, that the instructing of the genome reaches all the way up to the form and the function of the entire organism. In all this, this instructing has two overlapping tasks: (a) to shape, from its bottom position, the entire hierarchy of ontogenic self-organizing towards endowing the entire MO with its specific form, where all of the self-organizing agents – with the help of cues from each other and from environments – find their specific positions with specific connections to each other; and (b) to shape the functioning of all these agents, once they have found their positions, towards making the entire MO function (behave) in its specific ways.

BBF5. To succeed in producing a well-formed ("fit") MO, able to cope with its typically complex and changing environments, the ontogenic self-organizing needs inputs from these environments: always a certain minimum of nutrients and energy, to allow it to proceed; and often additional information, on top of the information supplied by its genomic instructions, to contribute to determining its specific form and function. The ontogeny of different species needs, and is able to use, different amounts of environmental information – relatively little for insects, and very much for humans, especially for the self-organizing of their brains. But, to allow environmental information actually to help, a necessary condition is that the ontogenic self-organizing build for it suitable input channels and processors (to begin with molecular switches). While environmental information may extensively help also with this building – its present contributions may help to shape the input channels and/or the processors for its future contributions – it cannot do so initially. As implied by the logic of information processing and documented by empirical facts, the first input channels and the first processors (switches) that environmental information needs to start to help – such as the first interconnection among neurons and sensors – must self-organize according to genomic instructions alone. These instructions are both what allows environmental information to contribute, and what limits the extent to which it may do so. Environments cannot help ontogeny directly, without sending their information through some previously self-organized input channels and processors. Their direct influences can only be disruptive – for instance, they may deform or interrupt the ontogenic self-organizing by lack of food or the wrong temperature. A trivial, but for economists (especially the development ones) potentially inspiring example is the embryo of a mouse: without food it will not develop, but no food will make it an elephant, and no environmental information will make it a mathematician.

BBF6. The ontogenic self-organizing process is far from egalitarian: some of the proteins are "switches," controlling the synthesis of other proteins, and some of the cells are stem cells, organizing other cells. It may also produce great inequalities in the form and function of the organism – for instance, it may develop a brain, whose cells, the neurons, control the functioning of many other cells.

BBF7. Phylogeny, in which genomes repeatedly play roles (C) and (D) is the complex of processes by which old species of organisms evolve or disappear and new appear – in other words, this is what Darwinian evolutionary theory is about. To play role (D), and thus allow phylogeny to proceed, genomes must allow some errors in their playing of the information-preserving role (C). These two roles must thus work to some extent against each other – to act as evolvers, genomes must somewhat fail as an information-preservers. It is important to realize that the lasting products of phylogeny consist of genomic messages – both the instructing ones and the "unproductive junk," if any – and not entire organisms, as these are typically variable and relatively short-lived. It is because of their relatively fragile biochemical nature that genomes need organisms as active memories to protect them against disturbances and propagate their messages over time. Genomes as the lasting products of phylogeny must therefore clearly be distinguished from their testing by possibly several levels of natural selection according to the performance ("fitness") of the organisms that they have been able, by their instructing during ontogeny, to obtain. Their instructing parts must thus succeed in obtaining, with more or less extensive help of environments, sufficiently "fit" organisms, and the "junk" must not disturb too much, otherwise both will fail to be selected.[5]

BBF8. A multicellular organisms that is moreover social (MSO) can be described as both needing and being able to associate and self-organize with similar organisms into a more or less large and more or less structured society (group, organization). The property of being social must also be genomically instructed: it is indeed specific to certain species, and not others. But the genomic instructing may use two methods: (i) specifying just one variant of social "rules-of-the-game" ("constitution," "particular social grammar") that each individual will instinctively obey; (ii) delimiting a more or less broad set of variants of such rules ("universal social grammar"), and endowing the individuals with abilities to search for and learn, within this set, by their own trials and errors, the specific rules of their actual society by themselves. Social insects exemplify (i), while homo sapiens uses the highest proportion of (ii). But some (i) appears always present: instincts are known to play important roles even in human social behaviors, and are logically needed as the starting point for the evolution of all

[5] It may be amusing to imagine that the non-instructing parts that we call "junk" are in fact the true aristocrats of the evolution, while the instructing parts are their workers and managers that toil hard to provide them with comfort and protection.

variants of human societies.

BBF9. Both methods increase the demands on the information that the genome must supply, and that the trials and errors of Darwinian evolution must therefore discover. For method (i), this information must precisely determine all the rules-of-the-game of a successful instinctive society, whereas for method (ii), it may only roughly delimit a more or less large set of variants of rules, of which only a few may be successful, and leave the MSOs free to search for one of these by their own trials and errors. Importantly, and perhaps surprisingly, more information is needed for (ii) than for (i). To be sure, less information suffices to delimit the rules of a successful society only roughly than to specify them with precision. But many times more information is then needed to endow the MSOs with all the required abilities for seeking, discovering, and learning the precise rules by themselves. The logical reason, well known from computer programming, is that a fixed behavior requires a shorter program than the learning of a comparable behavior in function of experience. The empirical evidence is that method (ii) is used only by genomes that also instruct the building of highly sophisticated brains – in particular those of homo sapiens, on which more later.

BBF10. Since the success of MSOs also depends on the success of their society, the performance tests of their genomes are correspondingly extended. In addition to the form and the function of MSOs as individuals, their genomes are moreover tested for the form and the function of the society into which they will self-organize and which they will make function. To see how the genomes may fail in this extension, consider a situation in which the MSOs are sufficiently "fit" as individuals and their environments are sufficiently hospitable, but their society is nevertheless unsuccessful. The possible failure depends on the method used: if (i), the genomes may build into their social instincts the wrong "rules-of-the-game"; if (ii), the genomes may fail to make them sufficiently talented to find and learn successful rules in time. Note that successful rules may then either be entirely outside the set of alternatives that the genomes allow them to seek and learn, or be in this set, but too difficult to find, given the limited searching and learning abilities that the genomes allow them to develop and employ.

Concerning the possible relevance of these facts to socioeconomic problems, most differences from usual views concern the four roles of genomes listed in *BBF3*. Social scientists interested in biology have usually focused on the replicating role – and that without distinguishing between (B) and (C) – and on the evolving role (D). For the building of SGD, in contrast, the most inspiring has been the instructing role (A), and the fact that this role is not played by entire genomes, but only by some of their parts. The reason is, as explained in more detail below, that both organisms and societies can be understood as outcomes of self-organizing (spontaneous ordering) of certain elementary agents, and that the difference between their success or failure most importantly depends on how these agents have been instructed, by what "rules-of-the-game" the agents' self-organizing and operating, while interacting with each other and with environments, have been shaped.

Attention to the difference between genomic replicating intra-organism (B) and inter-generation (C) is also rather unusual. Yet this difference is crucial for dispelling the still widespread confusion about the socioeconomic counterparts of replicating: (B) may be admitted as relevant – it may be seen to correspond to how some common "rules-of-the-game" spread among the members of the same organization or society – while (C) must be put aside as highly biology-specific. As already noted, socioeconomic organizations rarely have offspring, but more often last, evolve or dissolve as childless singles.

But this also means that SGD must admit that evolution may also take place during (B), and not only (C), in order to comprehend a society that both lasts and evolves, as its members are introducing and imitating changes of some of its characteristics – such as the rules of conduct studied by Hayek (1967) and Vanberg (1994). To leave (C) out of SGD is indeed crucial, as the difficulties with identifying the precise socioeconomic counterpart of inter-generation replicating have caused some of the greatest doubts about the possibility of generalizing Darwinism for sensible uses in the social sciences.

Since the social scientists learning from biology have usually focused on Darwinian evolution and phylogeny, some novelty may also be seen in the three BBFs that extend attention to self-organizing and ontogeny – namely *BBF4*, which shows that successful ontogenic self-organizing needs suitable genomic instructing, and that one level of such instructing may shape several higher levels of self-organizing; *BBF5*, which admits important influences of environments, but also makes it clear that the ways for these influences must initially be prepared and are ultimately limited by the instructing; and *BBF6*, which points out that far from egalitarian, ontogenic self-organizing may be run by unequal agents, which may then also become unequal functionally, possibly including a spontaneous emergence of a more or less extensive central control.

Last, but not least, some novelty may also be seen in the attention to the direct and indirect ways in which societies of organisms ultimately depend on the genomic instructing of their individual members, as brought to light by *BBF8*, *BBF9*, and *BBF10*.

But, once more, the sole purpose of this section was to reveal to interested readers what biological facts have most inspired the building of SGD. Emphatically, no one else need pay attention to them: starting with the following section, SGD will be built formally as an abstract conceptual framework, without directly reposing on any biological fact or analogy.

3 Agents, environments, and interactors

To start to build SGD in an orderly way, assume a set of agents of certain behaviors acting in certain environments, from which they are obtaining resources, including information. This allows them to self-organize into, and operate within, an interactor, which they consequently endow with a certain form and a certain function (behaviors, performance). Both the form and the behaviors of both the agents and the interactor may vary over time.

To benefit from Simon's (1969) clarification of the architecture of complexity, on which more in Section 6, the notions of agents and interactors are defined to admit flexible empirical interpretations. A large variety of real-world entities will be made possible to interpret both as interactors formed by smaller agents, and as agents forming a larger interactor. Instead of "agents forming interactors," it is thus also possible to say "small interactors form large interactors." Such agents-interactors can be exemplified by molecules, parts of cells, cells, multicellular organisms, societies of organisms, and socioeconomic organizations, which will be defined to include entire nations and national economies.[6]

The agents' behaviors have two possibly interdependent, but logically distinct dimensions: *associative*, which implies how, when self-organizing, they selectively interconnect and find their positions, and thus endow the interactor with a specific form; and *operational*, which implies how, in these positions, they specifically function (operate), and thus endow the interactor with specific behaviors.

A crystal and a computer are two extreme examples, involving agents that are active only in one of these dimensions. The atoms or molecules that are self-organizing into a crystal are often active only associatively. When the temperature and the pressure are right, they selectively interconnect and find their positions, but may do little after that. In contrast, the electronic agents of today's computers are active only operationally. They perform possibly complex logical and arithmetical operations, but their positions and interconnections must be established exogenously – wired or printed – as they would be unable to interconnect and find their positions by themselves.

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[6] Instead of "interactors," such entities are sometimes termed "systems." But there are two good reasons to avoid this term: it is too general, employed in very many different meanings, which may cause confusion; and, as its classical definition is "a collection of given parts interconnected in given ways," it is not well suited for denoting variably organized entities, in which both the parts and the interconnections may change. The term "interactor"was originally coined by Hull (1980) to denote an organism ("phenotype"), and is now used , in this meaning, in many biological essays, including HK-GD. Its present generalization extends this original meaning both downwards, to parts of organisms, and upwards, to societies of organisms.

To visualize the general case of agents active in both dimensions, imagine a futuristic computer, whose parts not only operate, but moreover self-assemble (self-organize). To construct such a computer, it suffices to produce its individual parts endowed with suitable associative and operational behaviors, endow them with enough energy, and let them free to seek their partners, establish connections with them, and thus finish the construction all by themselves. If their behaviors are sophisticated enough, they may even be able to adapt and develop the construction in response to certain inputs from environments and/or in function of their own searching, experimenting, and innovating. This case is important to grasp, as it is of such agents that both organisms and societies are made.

In economics, this case is still only little explored. Perhaps the closest reference is Hayek's (1973) view of spontaneous orders formed by individuals following certain common rules of conduct. But there are three differences. One is the distinction between the individuals' associative and operational behaviors, made here, but not by Hayek, and another is the sharp distinction between spontaneous orders ("taxis") and purposeful organizations ("nomos"), made by Hayek, but not here. As will become clear below, SGD admits that a spontaneous order may evolve into an organization which develops an objective (purpose) of its own, while much of an organization may grow into a spontaneous order escaping the control and deviating from the purposes of its founder(s).

A third difference concerns the issue of centralization vs. decentralization. Spontaneous orders are often associated with decentralization and equality of influences, and thus opposed to central control. In contrast, SGD admits that self-organizing may not be very egalitarian, nor the functioning of the self-organized interactors very decentralized. Even if all the agents involved are both associatively and operationally active, some of them – such as enzymes among macromolecules, stem cells among cells, and entrepreneurs among economic agents – may contribute to the self-organizing much more than others; and some of them – such as neurons in organisms, chiefs of primitive tribes, and policy-makers in developed economies – may influence the functioning much more than others. Interestingly, neither the inequalities of influences nor the most influential agents need be the same during the self-organizing and during the functioning. For instance, a largely decentralized self-organizing may produce a highly structured hierarchy of functional control – as can be illustrated by the self-organizing (embryogeny) of organisms with a brain.

Outside economics, self-organizing – more usually called "self-organization" (although this term expresses less well that this is a process, and not a state) – has been the topic of a rapidly growing and ramifying literature.[7] With much of it, however, SGD has only distant relations. While self-organizing has often been presented as a highly complex, possibly chaotic, and in any case difficult to understand process, SGD brings to light its relatively simple basic principles, that too much attention to its possible complexity often appears to obscure – namely, that this is a process run by a set of agents which, in function of their internal abilities and external conditions, selectively associate and thus form orderly structured larger interactors.

What may cause complications is that the agents' associating may be long, repeatedly tentative, and possibly never stabilizing. The agents may try and then reject different interconnections, be assigned and then demoted from different positions, and some may even leave or be ousted, while new agents may be joining. Any of this may indeed cause difficult to understand complexity, instability and possibly even chaos. But the importance of such difficulties must not be overestimated. In most of the most interesting interactors – including organisms, economies and societies – the self-organizing of their agents typically displays important regularities that endow them with relatively stable features, possible to understand as due to the agents' associative behaviors, including the ways in which the agents respond to each other and to their environments.

The key role of associative behaviors deserve emphasis. It was insufficient attention to them that made it possible to present self-organization as a quasi-miraculous paradox violating the Second Law of Thermodynamics (Prigogine and Stengers, 1984). The paradox rapidly disappears when it is realized that this law is about interactions of associatively non-selective agents – chemically inert gas molecules, often exemplified by "billiard balls" – while in both organisms and societies, self-organizing agents are typically associatively selective – to begin with the different chemical affinities of atoms and molecules. Such agents often only need the right environmental conditions – such as the right temperature and pressure – to self-organize into highly ordered entities. While favorable environmental conditions are necessary, they are only auxiliary – it is not on them, but on the intrinsic associative behaviors of the agents that the resulting order most fundamentally depends.

Another difference from much of the self-organization literature is that SGD also pays attention to what happens "after." While many students of self-organizing only consider the possibly admirable forms that certain self-organizing agents can be shown to produce, SGD also follows how these forms will function and perform.

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[7] For an excellent introductory sample, see the collection of studies in Camazine et al. (2001). Perhaps the most points of agreement with SGD can be found in Doursat (forthcoming).

As will become clear in Section 6, to pay proper attention to both the self-organizing and the functioning of the self-organized entities is particularly important in search of understanding of complex multilevel interactors. This will indeed prove to be the only way clearly to grasp the entire chains of effects from the behaviors of small individual agents to the behaviors of the large interactors into which the agents through several organization levels self-organize and which they consequently make function – perhaps the most interesting and most challenging example being the chains that lead from the genomic instructing of specific proteins and RNA-regulators to the form and the behaviors of entire human individuals.

4 Instruction-based behaviors and doubly instructed agents

Following the basic logic of information processing, SGD defines all behaviors, of both agents and interactors, as instruction-based. Whatever an agent or an interactor does is attributed to some instructions that guide it to do so, and that are stored in some memory belonging to it . This generalizes the increasingly adopted view that all human mental processes, including economic decisionmaking, are in a certain sense program-based.[8]

What makes the term "instructing" particularly suitable for uses in generalizations is the breadth of its possible interpretations – from strict programming, forcing its users to follow narrowly specified routines, to broad constraints ("rules-of-the-game," "negative rules"), determining ranges of permissible behaviors, within which the users are free to choose their actual behaviors. But note that in this case they must also be instructed, from another source, on how to use this freedom. Formally, the constraint-interpretation suffices, for it may be seen to include programming as the extreme in which the constraints make the permissible range so narrow that the agents are forced to follow specific routines.

To see that this term also applies to human mental processes, without reducing humans to mechanistic automata, it is important to realize that instructing may also concern, and is needed for: (i) responding to inputs from environments, including fellow agents; (ii) modifying actual instructing by learning; and (iii) experimenting by imperfectly informed (probabilistic, more or less random) trials together with systematic elimination of what the instructing defines as errors. Instructing (i) makes the agent responsive, (ii) makes it adaptive, and (iii) makes it creative and innovative – or at least able to proceed, and not get stuck, in

[8] For particularly clear expositions of this view, see Holland (1995), Cosmides and Tooby (1997), and Vanberg (2004). The present generalization replaces the term "programming" by the broader "instructing," and extends attention from the behaviors of humans to the behaviors of agents and interactors of any nature.

absence of important information.[9]

Note that even behaviors with such advanced features as "intentionality" and "consciousness" may, and indeed must, be instructed. The former by instructions for how to value the outcomes expected and/or obtained – possibly expressed in terms of norms, preferences, or objective functions – together with instruction for guiding actions towards obtaining more valued outcomes. Consciousness needs higher-level instructions for how to observe and guide, more or less incompletely and imperfectly, the uses of lower-level instructions for controlling actions.

The main point of all this is that at any moment, the actual behaviors of all agents and interactrors – including their receiving, using and responding to inputs from environments, learning and adapting, and creating and innovating – are implied by their actual instructing. This also means that they must be recognized unable to do anything for which they lack instructions.

This raises the question of where the instructing of an agent-interactor may come from. SGD divides its sources into three types: initial instructing, external instructing, and own learning from acquired data ("experience"). Note that in terms of the classical "nature vs. nurture" debate, initial instructing corresponds to "nature," and external instructing together with acquired data, to "nurture."[10]

In a first approximation, the actual instructing may simply be viewed as an amorphous mix to which the different sources may have contributed in different *quantitative* proportions. But this view is not very enlightening, although many participants of the "nature vs. nurture" debate appear satisfied with it. For full clarity, it is necessary to understand the *structure* of this mix, in particular the ways in which different sources may or must cooperate, and thus condition each other's possibilities to contribute to it.

The key to this understanding is an elementary, but not always fully realized principle of all information processing: *no information can be understood and effectively used without pre-existing information on how to do so*. This implies that an agent may receive and put to effective uses new external information, including external instructions, only in those ways that its actual instructing allows it to follow.

This principle has three important consequences. First, only a limited – and possibly

[9] Note that agents that are instructed, and therefore able, to take in certain situations random (unrelated, arbitrary) steps cannot be reduced to deterministically working Turing machines. This is also why they need not come to a stop in choices among equally preferrable but mutually exclusive alternatives – as opposed to the proverbial Buridan's ass that starved to death between two equally distant and equally attractive heaps of hay.

[10] Computer uses may find it helpful to compare the three sources to of the initially given hardware, the added software, and the input data that determine the actual behavior of a computer.

even empty – subset of an agent's actual instructing may be of external origins. Thus, an agent's behaviors may be based only on its initial instructing – this may be complete and closed, like the one of a clockwork automaton – but not only on external one.

Second, how any external instructions given to an agent at a certain moment may effectively influence its behaviors depends on, and is constrained by, its actual instructing at that moment. Thus, external and actual instructing do not simply sum up: the former cannot directly put in what the latter may be missing – in other words, the former is no substitute for the latter. On the contrary, extensive and sophisticated external instructing, to be received and effectively followed, requires extensive and sophisticated actual instructing.[11]

The third consequence concerns the fundamental role of the initial instructing, which is not always properly appreciated, especially in agents that this instructing endows with extensive learning and meta-learning abilities – most acutely exemplified by human brains. The reason for this lack of appreciation appears to be that the actual instructing of such agents makes them increasingly able to use increasing amounts of external instructions and data for continuously and extensively developing itself. After a while, the accumulated contributions of all the external information to this development may *quantitatively* far exceed the contributions of the initial instructing, which may thus appear increasingly negligible.

Intellectual effort may therefore be needed to realize that the initial instructing is and remains *structurally* fundamental. This can be done by anatomizing the development of actual instructing into a sequence of stages, where the contributions of external instructing and data may eventually become overwhelming, but where each stage depends on, and is limited by, the actual instructing elaborated for it during the preceding stages. This makes it easy to see that any such multistage process must have some initially pre-instructed beginning – its stage "one" – without which it could not start and by which its entire development, however rich and ramified it might become, is ultimately constrained. As external inputs and learning may only be used in actually instructed ways, they may start contributing only from stage "two," after the first instructions for using them have been installed. Initial instructing must therefore precede and be independent of all external information. This is the prime ingredient that is needed to allow any development of actual instructing to start, and that sets limits to what this development, in the most ideal environments, may possibly achieve.[12]

[11] To see why, it may be helpful to think that programmable computers must contain more internal instructing – the more so, the more extensive their programmability is to be – than single-purpose computers.

[12] For human brains, this logical implication is also corroborated empirically: while their development may increasingly depend on environmental stimuli, it is genomic instructions alone that guide the formation of the first neuronal interconnections. At this initial stage, environments may only disturb or disrupt, but not guide.

To correspond to the two dimensions of agents' behaviors, instructing is also seen to have its associative and operational dimensions. Agents that are both self-organizing into, and functioning within, an interactor may therefore be seen as "doubly instructed" – associatively, to know how to interconnect and find their positions when self-organizing; and operationally, to know how to act and interact from these positions.

While the two dimensions may overlap, as some operating instructions may also affect self-organizing and vice versa, distinguishing them is possible and often helpful. This appears to be the only way clearly to understand the above-mentioned and below-examined chains of effects from the instructing of individual agents to the form and the behaviors of the possibly complex interactors into which the agents self-organize and which they make function. To see the agents equipped with two different types of instructions – how to find their positions in the interactor, and how to operate in the positions found – helps to organize the study of such chains, and to realize why they often are so difficult to understand and actually follow. Namely, the two types of instructing may largely be independent, containing little information about each other. Observing how agents self-organize informs about their associative instructing, but may leave in obscurity the operational one. It may be as if they kept the latter in sealed envelopes that they will not open until their self-organizing has sufficiently advanced to determine their first operating positions.

Note that such obscurity is a predicament already for chemists: while the associative instructing of all atoms is rather well known from their chemical valences and affinities, and the structures of the molecules into which different atoms may self-organize are therefore relatively easy to foresee, it is much more difficult to foresee how the atoms will interact within the molecules, and how these will consequently behave. Emphatically, however, such obscurity is only a problem for external observers: whether it is clear to them or not, the double instructing of associatively and operationally active agents must in a certain sense exist and have definite effects, which may be both highly significant and far-reaching – as in the above-mentioned example of the DNA instructing of individual proteins and RNA-regulators that significantly affects the form and the behaviors of entire multicellular

Intuition may be helped by thinking of the seed of a large tree that is also quantitatively negligible, yet structually crucial: it is needed to allow the tree to start to grow, and it implies the maximum size and ramification which this growing may possibly attain. While this corroborates the way in which the "nature vs. nurture" controversy is explained by Ridley (2003), the title of his book is implied to be a misnomer: as all the ways through which environments – the "nurture" – may help to develop human minds must start with a suitable genetic instructing – the "nature" – the correct title appears to be "Nurture via Nature," and not the other way round.

organisms, and, for the social ones, also their societies.[13]

5 Success criteria and instruction bases of interactors

To understand the behaviors of both agents and interactors, it is often helpful and sometimes necessary to consider them subject to certain success criteria, which may be divided between internal and external. The former correspond to the objective(s) that an agent-interactor pursues, or may be seen to pursue – possibly expressed in terms of a preference ordering or an objective function that it may be seen striving, under various external and internal constraints, to maximize. Whether it does so "intentionally," as can be said about a human, or only "as if," as can be said about a goal-seeking robot, is here unimportant. Both can be understood as guided by instructions in which some internal success criteria (objectives, norms) are encoded. Seen from outside, the two may therefore be considered formally equivalent.[14]

The external success criteria may be thought of as those of "fitness," "survival," or "sustainability." They value agents-interactors for their abilities to deal with their environments to obtain the resources, including information, that the agents-interactors need for maintaining their form and function. For a multi-agent interactor, the external criteria also include demands on its internal cohesion: it must be able to keep its constituent agents sufficiently together, self-organizing, operating and interacting in ways that allow it to meet all of the external criteria.

A priori, there is no guarantee that all the different success criteria concerning an interactor and its agents are in harmony. It may happen that an agent's internal goal-seeking works against the external success both of itself and of the interactor to which it belongs, and on whose success its own success may thus also depend. Or it may promote its own external success in the short run in a way that undermines the external success of its interactor, and thus also undermines its own existence, in the long run.

To illustrate, consider that the objectives pursued by human individuals may conflict with the objectives of both their cells, especially if these turn cancerous, and their economy. This may behave as if stubbornly pursuing some by them unwanted objectives, such as low growth and high unemployment, while their pursuit of their individual objectives may harm it,

[13] Note that the notion of instructed self-organizing involves an even deeper hidden order than the one of adaptive rule-following behaviors exposed by Holland (1995). In present terms, this only hides the chains of behavioral instructions and instructions for changing these instruction that produce observable adaptive behaviors, comparable to an already assembled computer program. But underneath is hidden the instructed self-organizing by which all these chains of instructions have been properly assembled, from their elementary parts, without any superoior intructor (programmer).

[14] A clear explanation of this equivalence is in Vanberg (2004).

such as not contributing enough to the supply of, or even detracting from, some of its essential common goods.

To allow a multi-agent interactor to keep meeting all of its external success criteria, a certain minimum harmony between these and all the internal and external success criteria of its agents is therefore necessary. An economist may say that the interactor must contain reasonably efficient solutions of its incentive problems.

Moreover – and this what economists still often overlook, wishfully assuming to be always the case – the interactor must also contain reasonably efficient solutions of its competence problems, to make sure that the agents' are sufficiently instructed (competent, rational) for their positions, in order actually to succeed, according to such harmonized success criteria, and thus allow it to succeed. In Heiner's (1983) words, the interactor must also be able to prevent its agents from causing fatal "competence-difficulty gaps."

If these problems have a solution, this must have the form of agents' instructing. The agents of a successful interactor, or at least a sufficient proportion of them, must be so suitably instructed that they can do, during their self-organizing and operating, all that the interactor's success requires. But what instructing, if any, may be so suitable depends both on the abilities of the agents, as implied by their actual instructing, and on the severity of the environments. Three cases are important to distinguish:

(1) *Success impossible*: The environments are so harsh in relation to the agents' abilities that no instructing can allow the agents to form successful interactors, and possibly no organized interactors at all.

(2) *Always success*: The environments are so hospitable and the agents already so suitably instructed that organized interactors can form, and all are successful.

(3) *Success possible but rare*: The environments are sufficiently hospitable, so that organized interactors can form, but the agents' actual instructing is insufficient, so that only some of these interactors would be successful. The agents therefore need suitable additional instructing to guide them to form and operate only some of the successful interactors, while excluding all of the failing ones. The relatively scarcer the successful interactors are, the more extensive (informationally rich) the additional instructing must be. Importantly, the agents' actual instructing, although insufficient for the self-organizing and operating of a successful interactor, must nevertheless suffice for receiving and adopting the needed additional instructing. Thus, for reasons explained in the previous section, they cannot be informationally empty "blank slates." If the needed additional instructing must be extensive and sophisticated, their preexisting actual instructing must be correspondingly so.

Only cases (2) and (3) are here of interest. They raise the question is of the sources of the suitable instructing, including the actual isntructing of the agents, and in case (3), the additional instructing common to the interactor. Another question then is, how can the additional instructing be expressed, stored, and effectively added to the agents' actual instructing?

It is for dealing with these questions that SGD introduces and makes central the general notion of "instruction base" – defined as the collection (logical sum) of all the additional instructions needed by a set of agents in order to self-organize into, and operate within, a successful interactor. This appears to be SGD's main novelty.

Logically, instruction bases are properties of interactors. Materially, however, it is possible that they do not exist in another form than dispersed in the memories of the interactors' agents, as a kind of the agents' common good. If the agents of an interactor are differently specialized, its instruction base may contain correspondingly specialized parts, while other parts may be common to several, or even all specializations. The agents may then have to store and use only those parts that are relevant to their specialization – although they may also store the entire instruction base, and just keep the for them irrelevant parts silent.

The instruction base of an interactor has two distinctive features: relative stability, and the nature of information. While the interactor may within certain limits flexibly change – its agents may entry or exit, modify their interconnections, and change their behaviors – its instruction base may remain constant, and thus provide the needed rigidity that must underlie, as Hofstadter (1979) made it particularly clear, every flexibility. And while the forming and functioning of an interactor typically require substantial amounts of materials and energy, the essence of its instruction base is information. Although some materials and energy are also needed for its storage and uses, they are secondary: basically the same materials and energy may be used for the storing and using of a great variety of different instruction bases, belonging to a great variety of different kinds ("species") of interactors. It is the information contents of instruction bases that makes the difference, and is therefore primary.

Returning to the question of what is the ultimate source of suitable instructing, it has two conceivable answers: (1) an initially instructed (informed) exogenous interactor – possibly called "organizer" or "creator"; or (2) a Darwinian evolution, which can be viewed as a trial-and-error search consisting of uninformed (random, blind) trials that at first forms any feasible interactors, rejects the failing ones, and selectively preserves the instructing that happened to lead to successful ones.

To some extent, the two answers may mix. The exogenous organizer may be informed only imperfectly, and thus produce only parts of the needed instructing, while having to run a Darwinian trial-and-error search process for producing the rest. In this case the trials are not entirely blind, but, depending on the limits of the organizer's information, only more or less incompletely informed. Such an imperfectly informed organizer running a such a limited Darwinian process may suitably be called "experimenter."

In sufficiently complex interactors consisting of sufficiently complex agents such limited Darwinian processes producing additional instructions and other new information, may also be conducted endogenously by some of the interactor's agents, as an integral part of their self-organizing and/or operating. Examples are the experimental production of immunological defenses (antibodies) in organisms, and the experimental creation of firms and introduction of new technologies in economies. But such endogenous Darwinian experimenting cannot belong to the ultimate sources: agents can run it only in those ways and to that extent for which they have been previously instructed. The question concerns the ultimate origins of all of their instructing, including the one for any limited Darwinian experimenting that they might be able to conduct.

For this question, virtually all od today's biologists and most of social scientists only admit pure (2): full-fledged Darwinian evolution which need not, and leaves no room for, any pre-informed (intelligent) exogenous organizer. In this variant, the central position of instruction bases is particularly clear. They constitute the central divide that splits the genesis of successful interactors into two types of stages: (I) the production of the needed additional instructing by Darwinian trial-and-error evolution, and (II) the use of the instructing produced during the actual forming of specific interactors. SGD labels (I) as "general phylogeny" or "evolution proper," and (II) as "general ontogeny" or "development."

No deep knowledge of biology is needed to see that biological phylogeny and ontogeny are indeed special cases of the general phylogeny and ontogeny, and that the genomes of organisms are special cases of the instruction bases of interactors. But in SGD, the distance between the general notions and their biological versions is greater than in existing variants of GD. In particular, there are three features of biological phylogeny and ontogeny for which generalizations have been sought, but that SGD leaves aside as too biology-specific.

One concerns the speed difference between the two processes. Biological phylogeny is so much slower than biological ontogeny that each organism can usually keep its genome constant during its entire development from conception to death. In contrast, general ontogeny and phylogeny – and, as considered in more detail below, also their socioeconomic versions – may proceed at more comparable speeds, and thus often overlap. An interactor's instruction base may suddenly change (evolve) long before its development is finished, and then force the development to continue, from the actual state attained under the old instruction base, by following a new trajectory implied by the new base.

Another too biology-specific feature is the Weismann barrier that prevents outcomes of biological ontogeny from contributing to biological phylogeny – best known for excluding inheritance of acquired (learned) abilities, as claimed to exist, but never irrefutably demonstrated, by advocates of Lamarckism. In general, however, contributions of outcomes of ontogeny to phylogeny cannot be excluded, and in socioeconomic evolution, as considered in Sections 7 and 8 below, they must be admitted.[15]

The third too biology-specific feature is the inter-generation replicating of (parts of) genomes, necessitated by the relative fragility of biochemical memories. It is because of this fragility that the instruction bases of successful organisms, to be preserved over long periods of time, require a series of generations of interactors, where offspring are repeatedly formed from scratch, receiving, applying, and if necessary correcting, the instructions of their parent's genomes. But in general, instruction bases may use memories of more reliable kinds which makes their inter-generation replicating unnecessary. For example, although socioeconomic organization may sometimes also use inter-generation replicating – such as the founding of a new tribe by emigrants from an existing tribe, or the spin-off of a new firm by employees leaving an existing firm – this is not typical. Much more often they lack offspring, and instead last and evolve or dissolve as childless singles.

Only one kind of replicating can be generalized: the one among the agents of the same interactor. In an interactor of any nature, its instruction base must be sufficiently replicated among its agents, to provide them with all the relevant additional instructions that they need for making the interactor successful. This kind of replicating may be denoted as "intra-interactor." A problem may be that there may also be several generation of agents within one interactor – such as several generations of cells within one organism, and several generations of individuals within one society. It is therefore important to identify the interactors whose evolution is being studied, and clearly distinguish their generations, if any, from the generations of their agents. What is here defined as "inter-generation replicating," found too biology-specific, and therefore excluded from SGD, concerns the interactors' generations.

[15] As noted in the introduction, SGD thus agrees with Nelson and Winter (1982), who understand the evolution of economies as containing elements of Lamarckism, and not with Hodgson and Knudsen (2007), who reject Lamarckism in all of its applications.

Note the importance, for each evolutionary study, of carefully distinguishing which kind of replicating may be generalized, and which one cannot. To insist on finding meaningful socioeconomic counterparts to all the functions that "replicating" and "replicators" perform in biology is bound to cause confusion, and may unjustly discredit Darwinism as entirely unsuitable for studies of socioeconomic evolution.

While the three differences from biology are important to keep in mind, in order not to exaggerate similarities and thus discredit the entire generalization enterprise, it is nevertheless the similarities that matter most. An important feature that the general and the biological versions of phylogeny and ontogeny have in common is that they significantly differ in inertia – in other words, in their possibilities to admit rapid radical changes. During phylogeny, instruction bases may remain stable for long periods of time, yet possibly change quite suddenly, by "shocks" or "punctuations." In contrast, the consequent changes of the interactor's form and function during their ontogeny must be gradual, needing substantial time to unfold. To recall, instruction bases are pieces of information, whose symbols can change swiftly, whereas agents and interactors are more heavily "material," and thus need more time to realize any changes.

Note that all this helps to settle the long-standing "units of selection" controversy. While the actually developed successful interactors may be much more visible and tangible than their instruction bases, SGD makes it clear that it is these potentially stable bases, and not the inevitably more variable and possibly shorter-lived interactors, that constitute the lasting output of evolution. This reduces the controversy to the size of the units of selection – in biology, to whether they may be single genes, or must encompass larger segments of genomes. But whatever their size, the units may, logically, only be parts of the instruction bases that can repeatedly guide certain types of agents in certain types of environments to self-organize into, and operate within, successful interactors – and not the interactors themselves.

6 Instruction bases of multilevel interactors

To complete the building of SGD, it remains to be explained how it can decompose complex interactors into hierarchies of simpler single-level ones, along the lines of Simon's (1969) elegant view of the architecture of complexity.

The first step is to identify for all the interactors involved the relevant instruction bases. This means to establish, next to the hierarchy of agents-interactors, the corresponding hierarchy of instruction bases. Two facts are important to realize. First, the two hierarchies do not mix. To recall, instruction bases consist of pieces of information, whereas interactos are "material bodies" that actually form, develop and function. To be sure, instruction bases are integral parts of their interactors, and much of the latter may have to be used for realizing and preserving the former – perhaps most extremely in viruses, which are only little more than realizations of their instruction bases (RNA-genomes). But conceptually, the two remain sharply distinct.

Second, the two hierarchies may contain different number of levels that need not correspond to each other. Agents of some levels, thanks to how they have been formed by their agents of lower levels, may already have all the instructions they need to form successful interactors. For them, the relevant instruction base is the one of the lower-level agents. At their own level, no additional instruction base is necessary, and often possible. Recalling the three cases of conditions for the forming of successful interactors, such levels belong to case (2) – "(nearly) always success." Only levels that belong to case (3) – "success possible but rare" – need instruction bases of their own.

In an extreme, the hierarchy of instruction bases may contain only one level, for the first level of interactors. These may be so cleverly instructed that they give rise to several higher levels of increasingly complex interactors that will all be so well instructed for their self-organizing and operating that they can always – or at least sufficiently often – be successful, with no need, nor room, for any higher-level instruction base.

Despite its extremity, this case is in fact most common, comprehending a vast majority of life on Earth. Among the very few exceptions, the most prominent one, on which more below, is the case of humans and their societies, where two or more levels of instructions bases are both possible and necessary. But nearly all of the other species, even the social ones, repose on instruction bases of only one level – the DNA instructing of the synthesis of their proteins and RNA regulators. The biological interactors of all the higher levels unfold from there as a cascade of "sufficiently often successes." For most of the social species, this includes even their societies – corresponding to what Dawkins (1982) evocatively termed "extended phenotypes."

At this point, it is useful to recall and emphasize that SGD is no ally of the naive genetic determinism. A successful interactor is not claimed fully determined by its instruction base: this is admitted to accord extensive roles to environmental influences. As Section 4 made it clear, instructions need not determine the course of events directly and unconditionally, but may only specify how to respond to a certain repertory of inputs from environments and adapt actions and behaviors to these inputs. SGD thus fully admits that successful interactors may, and often must, largely be shaped by their environments. And, as interactors of increasingly higher levels may be increasingly complex, they may also develop increasingly sophisticated ways of adapting to their environments, and possibly even adapting the environments to themselves.

On the other hand – and this is equally useful to recall and emphasize – while instruction bases are far from fully determining the development of their possibly multilevel interactors, they nevertheless impose hard constraints on what this development, in the most ideal environments, can achieve. Quantitatively, as explained, environments may contribute to the forming and functioning of an interactor far more than its instruction base, yet this remains structurally crucial: they cannot contribute more than this base permits them to do. Note that this is true even for a sophisticated instruction base that permits environments also to contribute to the development of the ways for their future contributions. The permission is then only indirect, but not softer: the base directly constrains this development, which in turn constrains the contributions.

But all of this is only one part of the multilevel story. While the effects of instruction bases may thus be more or less direct or indirect, and may span over a more or less large number of levels in agents-interactors hierarchies, they all go in the same bottom-up direction. What must also be considered is that there may be significant top-down effects: an interactor may be influencing (shaping, conditioning) the form and/or the behavior of its agents, over and above what all of its instruction bases may do. The often discussed conditioning of individuals by their society, and of cells by their organism, with the resulting differentiation and specialization of the conditioned agents, are perhaps the clearest examples. The existence of top-down effects is particularly clear in the biological example: since all of the differentiated cells started with exactly the same initial instructing, there is no other explanation why they have become so different. Not to forget the possibilities of top-down effects and clearly show their place in SGD is important not only because they often matter, but also for definitely dispelling all suspicion that SGD might be naively reductionist, unable to take them into account

Top-down effects of interactors on their agents are indeed important both in reality and in scientific research, where they were often receiving much more attention than the bottom-up influences of instruction bases on their interactors. For instance, many social scientists used to concentrate so much on how individuals are conditioned by society, that they neglected to examine how society is formed by individuals. That this forming might further depend on human genomic instructing ("human nature") was nearly always ignored or even denied.[16] Top-down influences were also misused in arguments trying to refute reductionism and prove holism.

SGD puts things right by bringing to light two important, but often overlooked points. First, top-down influences may only be secondary, in the sense that the influencing interactor must first be formed and to a certain minimum extent developed bottom-up by some of its initially instructed agents, before it may start to exert any top-down influences on them. In other words, top-down influences may only emerge as a feedback reply to bottom-up influences.

Why this has not always been clearly seen may be that in the most interesting interactors – such as multicellular organisms and human societies – most of the top-down influences may affect other agents than the authors of most of the bottom-up influences. If an interactor lasts over several generations of its agents, then most of the bottom-up influences may be produced by a few initial generations, while strong top-down influences continue to work even for later generations. Superficial observers who only consider some of these may thus be fooled into believing that only top-down influences matter.

Second, top-down influences may only work with agents that are sufficiently sophisticated to let themselves be influenced. Clearly, they cannot do much if the agents' behaviors are rigid, with no inputs for them. This leads back to the instruction bases, on which the agents' sophistication depends: by constraining what the agents may possibly achieve they also constrain how and to what extent the agents may be conditioned by top-down influences of any higher-level interactors. Note that these constraints are germane to those on how the agents may be influenced by environments: an interactor's top-down influences may indeed be described in terms of what is often called "internal environment," consisting of the influences that its agents exert on each other.

All of this confirms that instruction bases remain central even in multilevel interactors. Each of their levels implies guidance and constraints for possibly several higher levels, including the uses of inputs from external and internal environments (top-down effects), and the possibilities of admitting instruction bases of the higher level(s).

The constraint on higher-level instruction bases deserves particular attention. This can explain why, in the evolution of life, the use of single-level of instruction bases is so widespread and their higher levels so exceptional. As explained in Section 5, any additional

[16] Prominent examples of the pioneers starting to take the genomically (evolutionarily) determined human nature into account are Cosmides and Tooby (1997) and Pinker (2001).

instructing requires agents whose internal instructing is so highly sophisticated that it allows them to receive, internalize, and actually follow additional instructions. The scarcity of higher-level instruction bases thus follows from the scarcity of such highly sophisticated organisms.

A simple comparison of ants with humans may help to clarify this point and provide a convenient introduction to the rest of this paper (cf. Pelikan, 2003b). Both species are social as their DNA instruction bases instruct them to self-organize (in usual environments) into societies. But the DNA instructing of ants also sufficiently specifies the form of their society, so that they need not, and would be unable to use, any higher-level instruction base. In contrast, the DNA instructing of humans only delimits a broad variety of their possible societies, that they might potentially form and to which they might adapt, without specifying which of these societies actually to realize. But, as history has many times demonstrated, far from all of these societies may lastingly be successful (viable, sustainable). In other words, this is (at best) a case of "success possible but rare," for which some additional instruction base or bases are indeed necessary. Thus, instead of providing humans with a ready-made instruction base of a successful society, their DNA instructing makes them sufficiently sophisticated to be able to search for, and hopefully also find and adopt some higher-level instruction base(s) for a successful human society themselves, but without any guarantee of success. This search is what SGD implies is the driving force of socioeconomic evolution, the topic of the rest of this paper.

7 Institutions as the instruction bases in socioeconomic evolution

In search of socioeconomic applications of SGD, the first task is to define the corresponding meaning of the three key notions: the smallest agents, interactors, and instruction bases. As usual in today's social sciences, it is natural to define the smallest agents to be human individuals. But, as opposed to some of these sciences, and in particular to many economic theories, SGD excludes all simplifying and idealizing assumptions about their faculties – be it perfect rationality, perfect responsibility, perfect selfishness, extensive altruism, or sufficient equality (homogeneity) that would allow all of them to be represented by a single typical individual. Not to get a distorted picture of socioeconomic evolution, it is necessary to build on the faculties with which humans have actually been endowed by the biological Darwinian evolution. On this point, SGD agress with the Continuity Hypothesis advanced by Witt (2003, 2004) and Cordes (2006, 2007), and is open to new facts about these faculties, such as those sought by the evolutionary psychology following Cosmides and Tooby (1997).

But without waiting for more detailed discoveries, SGD can proceed and make interesting inferences from a few simple "human facts" that appear sufficiently obvious. Three are of particular importance:

*HF*1: In each human society, there are significant inequalities among the genomically instructed ("inborn") basic learning abilities, usually called "talents," of its individuals. Whether the distribution of different talents is normal ("bell curve"), as it often appears to be, is not very important. What matters most is that in every society, the very high talents that may learn to create very high social value if discovered, given the opportunity to develop and put to productive uses, are scarce.

*HF*2: The true state of an individual's talents may for a long time, if not forever, remain hidden, and the individuals may commit more or less large errors, depending on the actual development of their own talents, when judging the talents both of others and of themselves.

HF3: The development of human inborn talents is a path-dependent process that consists of several layers of learning of learning ("meta-learning"). The development thus depends on the entire history of the inputs and stimuli received, with particular importance of the early ones. It is on them that both the extent and the direction of the development most strongly depend.

These simple but essential facts have a few simple, but important implications. H1 implies that the most significant differences among human societies may be not in the individual talents present – for instance, as may be indicated by differences between their respective talent distributions ("bell curves") – but in the ways in which the talents present are being selected, developed and employed. What makes this implication important is that it largely disconnects socioeconomic evolution from possible differences in genomic endowments. Thus, in whatever sense some societies might be found inferior to other societies, the leading hypothesis is that they have suffered from unfortunate socioeconomic evolution, and not from some genomic inferiority of their members.

H2 makes the problem of selecting, developing and efficiently employing the best talents extremely difficult to solve. Neither they, nor the best talents for recognizing them are generally known, and no one's judgments about the two can a priori be trusted. Many may claim to know, but only a few may be right, and these few are also initially unknown. This implies that there is no straightforward way to an efficient solution. In the best case, this can only gradually be approached by a suitably shaped trial-and-error evolutionary process

(Pelikan, 2007). In every society, the solving of this problem is thus one of the tasks of its socioeconomic evolution.

H3 implies that humans are genomically endowed with enormous cognitive potential, but also causes high uncertainty about the direction and the eventual outcomes of socioeconomic evolution. Depending on early inputs, the path-dependence of the multilevel learning may cause human understanding explosively to grow, or on the contrary be blocked by different kinds of ideological or religious brainwashing. It thus endows humans with the potential to create and adapt to, at least in the short run, a very large variety of societies, of widely different economic performance and widely different forms and degrees of individual freedom, and leaves open the question of which society this will actually be.

An important question for evolutionary psychology is, whether this enormous variety of potential human societies may nevertheless have some genomic limits. Chomsky (1967), who logically deduced the existence of a common, genomically determined "universal grammar" limiting the variety of human languages, speculated that a similar "universal social grammar" may also limit, in the long run, the variety of human societies. His argument was, in essence and in present terms, that only if humans have some genomically given need for individual freedom, that can never be lastingly unlearned, may they hope that socioeconomic evolution will not end up with some highly manipulative and oppressive societies.

Turning to the definition of socioeconomic interactors, SGD logically includes in it all groups of individuals of all sizes and all non-zero degrees of organization – from small tightly organized families, tribes, workshops, firms and government bureaus, to more loosely organized national economies, nations and multinational unions. The whole humanity, however, is not included. To qualify as a socioeconomic interactor, a group must have some common instruction base, over and above the genomic endowment of homo sapiens, that provides it with some non-zero degree of organization.

This definition departs from usual views by putting under one roof both purposefully formed organizations and spontaneously ordered large societies – and thus effaces, as already noted, Hayek's (1973) distinction between "nomos" and "taxis." SGD simply reduces the difference between the two to a matter of degree, which may be described as follows. In the self-organizing and the functioning of any interactor, depending on its instruction base, different agents may play differently important roles, and may thus differently influence the objectives that it pursues, or may be seen to pursue. These objectives, or what may be seen as such, are always part of the interactor's emerging properties, and may coincide only imperfectly, if at all, with the objectives of any of its agents. In all socioeconomic interactors, some purposeful organizing and some spontaneous ordering, in different proportions, may thus always be seen at work.

Note that by starting with human individuals, socioeconomic applications of SGD are joining methodological individualism, but by also dealing with organized groups and societies, they dissociate themselves from all the naive variants of this methodology in which the existence of groups and societies is ignored or denied.

The definition of socioeconomic instruction bases employs a more usual notion, but in a novel way. SGD implies, as mentioned, that the instruction bases of socioeconomic interactors, including entire economies and societies, are "institutions" in the sense of "rules-constraints" or "rules-of-the-game" – as defined in institutional economics by North (1990) and advocated for uses in evolutionary economics by Pelikan (1992, 2003a, 2003c).

As also mentioned, the institutions of socioeconomic interactors thus logically correspond, through the general notion of instruction bases, to the genomes of organism. But this puts them in competition for this correspondence with two well-known alternatives: "routines," proposed by Nelson and Winter (1982), meaning the detailed procedures (programs, algorithms) that determine step by step the actual behaviors of economic agents, and "memes" proposed by Dawkins (1976, 1982), meaning any ideas that can spread (be replicated) from mind to mind. In this competition, "institutions" can then be seen in the middle: they form a subset of "memes," as some, but not all, memes also instruct human minds on how to form and make function organizations and societies, while "routines" form a subset of theirs, as some, but not all institutions may be so constraining that they require the following of specific routines.

The notion of "memes" as *any* ideas that replicate thus turns out to be too broad, at best corresponding to the entire genome of a multicellular organism, including all of the non-genic and junk segments, but not to genes, which, in addition to replicating, have the important task of instructing the protein synthesis, and thus crucially contribute to the organism's forming and functioning. At the other extreme, the notion of "routines" is too constraining, as many parts of routines are specific to individual agents, rather than common to an entire interactor. In contrast, all agents of an interactor may share institutions as the rules of their "common game," yet remain free to choose their idiosyncratic ways ("routines") for playing this game. By allowing individuals to chose behaviors from a more or less large sets of alternative "routines," the notion of "institutions" accommodates the crucial fact that intrinsic properties of individuals matter (Pelikan, 2003c).

Institutions are also empirically more tangible than the two alternatives. Memes are difficult to identify because of the enormous variety and heterogeneity of the ideas that may spread from mind to mind, many of which can hardly be considered significant factors of socioeconomic evolution. Routines are difficult to identify because large parts of theirs, as Nelson and Winter point out, consist of tacit knowledge. In contrast, many institutions can be found as clearly written laws, regulations, or charters. Even the unwritten ones, such as custom and other informal sociocultural norms, can be found extensively mapped by ethnologists and organizational theorists.

With the role of the instruction bases of socioeconomic interactors, institutions acquire the privilege to split socioeconomic evolution into its ontogenic and phylogenic stages. Considering the changes of an socioeconomic interactor over time, the ontogenic stages correspond to its development under its actual institutions; and the phylogenic stages to the evolution (possibly punctuated by radical reforms) of these institutions.

It is now easy to see why SGD, to be applicable to socioeconomic evolution, must drop the three above-mentioned features of biological Darwinism: the great difference of speeds between ontogeny and phylogeny, the Weismann barrier, and the prime importance of replicating. Although in a typical socioeconomic interactor, its institutions are relatively more stable than its actual form that is being continuously produced and developed by the ongoing self-organizing of its agents, they may nevertheless also change, and do so relatively more often than the genomes of organisms. In particular, they may suddenly change (evolve) by a formally legislated reform, or by an informal shift of social norms, while the development of the interactor is going on. The development must then switch to a new trajectory as instructed by the changed institutions, but must start from the actual state attained under the old institutions.

An instructive example is the transformation of the failing socialist economies of Eastern and Central Europe into more successful capitalist market economies. While much of the institutional change could be sudden – in East Germany, the formal institutions changed overnight – the new institutions had to start with the mostly obsolete and wasteful firms and industries developed under the socialist institutions (cf. Pelikan, 1992).

Why the Weismann barrier cannot be maintained is that the institutions of a typical socioeconomic interactor are mostly made endogenously, by its own past and present agents, which are human individuals with extensive abilities to learn – even if not perfectly and lastingly – from past experience and errors. While the tentative institutional changes that run the socioeconomic phylogeny are far from fully informed, which means that future errors cannot be avoided, they are not entirely random. They may be, and usually are, enlightened by what the individuals who contribute to realizing them have learned from the successes and failures of the institutions under which they lived, and possibly also of those that they could observe from outside. This is clearly a Lamarckian channel through which ontogenic experience may influence phylogenic changes. This explains why, as noted, SGD agrees with Nelson and Winter (1982) that economic evolution may partly be Lamarckian, and opposes the radical rejection of Lamarckism by Hodgson and Knudsen (2007).

The key feature that the general ontogeny-phylogeny distinction retains, after all these departures from biological Darwinism, may be understood as the distinction between playing a game according to given rules, and making the rules. This distinction is logically clear even if the game-players and the rule-makers are partly the same individuals, and even if they use some of their experience from their playing for their rule-making.

Note that SGD, by promoting institutions to such a privileged position, strengthens its links to existing social sciences. On top of its obvious links to evolutionary economics and other strands of socioeconomic evolutionary theorizing, this also links it to the rapidly growing field of (new) institutional economics. The evolutionary and institutional economists who search for contacts with each other, rather than enclose themselves in their own field, may thus appreciate SGD as a helpful tool for this search.

8 New tasks for new institutional economics

Institutions in the role of socioeconomic instruction bases increase the importance of institutional economics, but they also impose on it additional tasks. First, as socioeconomic interactors may form multilevel hierarchies, this role requires that "institutions" be defined as a clearly structured multilevel notion.

For example, the institutions of a national economy must clearly by distinguished from both the internal institutions of its firms and the supranational institutions of the economic union to which it may belong, with clarifications of how the different levels of institutions relate to each other. This means to clarify, in the national economy vs. its firms example: (i) which of the national institutions, such as laws and cultural norms, also apply to individuals within firms; (ii) how the form of a firm's internal institutions, such as its formal governance and informal culture, is constrained by national institutions; and (iii) which of these institutions effectively exert these constraints, such as the corporate law and the labor law.[17]

[17] Note that for a long time it has not been very clear how the new institutional economics following North (1990) with the focus on institutions of entire economies is connected with the one following Williamson (1985)

Second, in addition to the usual studies of their effects on transaction costs and other incentives, institutions must now also be studied as factors that both instruct, and are produced by, socioeconomic evolution. This means to examine how the actual institutions of an interactor instruct its development ("socioeconomic ontogeny"), and how they themselves evolve over time ("socioeconomic phylogeny").

Of course, the effects on incentives remain important. That individuals need the right incentives in order properly to put to work their self-organizing and operating abilities is undeniable – and may perhaps intuitively be compared to the need for the right energy levels to make atoms and molecules realize their specific chemical bonds. It is only that institutions also influence the self-organizing and operating behaviors of individuals, and through them, the forming and the functioning of their different socioeconomic interactors, in many other more subtle ways, that must also be examined.

At this point, the notion of institutions as "rules-of-the-game" turns out to have another important advantage: although under different names, several aspects of socioeconomic ontogeny and phylogeny have already been studied in existing literatures. For ontogeny, this is above all the evolutionary economics following Nelson and Winter (1982), who may be seen to follow and elaborate Schumpeter's (1912/34, 1942) view of economic development as "creative destruction." Although in this literature, institutions are rarely explicitly mentioned (and if they are, usually not in the present sense), it is possible to see them implicitly involved. This economics may indeed be understood as dealing with the development of an economy, by means of innovations and structural changes, mostly under the institutions of standard capitalism – including private property rights, freedom of enterprise and the legal framework of reasonably competitive markets. Attempts to introduce into this economics the notion of institutions explicitly as "rules-of-the-game," and extend it to other types of institutions – including different forms of socialism and different forms of government control in capitalism – are in Pelikan (1988, 1992, 2001, 2003c).

It is instructive to note the likely reason why this literature has been labeled "evolutionary," and why it contains so many references to Darwinism, despite its dealing with processes that are more logical to consider "developmental," and despite the fact that its grand old man Schumpeter distanced himself from Darwin. The reason appears to be that economic development must often be highly experimental, especially under capitalist market institutions, generating broad varieties of imperfectly informed trials (innovations),

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with the focus on governance of firms. This connection requires a clear distinctinction between the corporate governance of one firm from the corporate law constraining the forms of corporate governance for all firms.

elimination of the inevitably large proportions of errors (failures, inefficiencies), and selection of the usually small minority of true successes. Superficially, this appears indeed much closer to Darwinian phylogeny, with its varieties of random mutations and natural selection, than to the much more informed ontogeny, which its genomic instructing (enriched by the genomically instructed inputs from, and adaptations to, environments) that appears to guide it quite straightforwardly from an embryo to a well developed adult organism.

But despite this large difference in the extent of experimenting, economic development under given institutions and biological ontogeny under given genomes logically do correspond to each other. Note that the difference may not even be as large as it might appear. That economic development (or underdevelopment) significantly depends on the prevailing institutions, and may thus be considered extensively "instructed" by them, is now an increasingly recognized fact. On the other hand, biological ontogeny is not always very straightforward: it has been found often to commit and subsequently correct or eliminate many errors.

The cause of the difference is important to realize. What ontogeny must achieve in both cases is to make the agents self-organize into a working interactor where they assume well-defined positions with well-defined links to each other. The ontogeny of a complex interactor with differently specialized positions and differently competent agents must therefore solve the double problem of what economists call "mechanism design" and "job-assignment," in order to match the contents and the difficulty of the positions with the abilities of the agents. The main difference between the biological and socioeconomic versions is that the latter has many more degrees of freedom, and thus many more unknowns that it must determine. Although in both cases, the agents as well as the tasks are heterogeneous, the genomic instructing of biological ontogeny pre-determines a much closer matching between the two, and thus leaves less to be found by trial-and-error, than the institutional instructing of economic development. But in biological ontogeny, most of the different agents (from proteins upwards) are in advance very specifically shaped for their specific tasks – much more specifically than the five categories of babies for the five levels of jobs in Huxley's (1932) Brave New World! In economic development, in contrast, the talents of individuals, the design of tasks, and the matching of the two, are all initially much more uncertain. With the exception of primitive traditional societies, where hardly any economic development takes place, the institutional instructing together with the initially largely unknown talents of individuals remain far from determining their tasks, many of which may first have to be invented. Many more trials and errors may therefore have to be made before enough tasks are suitably both designed and assigned, and a working economy formed.

There is another important reason why, despite this larger extent of trial-and-error experimenting, economic development under given institutions corresponds to ontogeny, and not to phylogeny. The crucial difference from phylogeny is in the character of the selection by which errors are recognized and eliminated. In phylogeny, this selection is "purely natural" – that is, subject only to general natural laws. In both ontogeny and economic development in contrast, it is subject to specific additional instructing, from genomes in organisms, and from institutions in socioeconomic organizations. Thus, contrary to what some evolutionary economists appeared to believe, the selection by market competition is not "natural," but significantly instructed (conditioned) by the prevailing institutions – such as property rights, competition law and bankruptcy law. An important link between the two levels of selection is that the natural one tests instruction bases also for their instructing of the internal selection: if they allow it to be too weak or too slow, letting serious errors (inefficiencies) last uncorrected, their entire intercators will prove "unfit," and they will themselves fail to be selected.

Concerning socioeconomic phylogeny, institutional economics appears more advanced. There is an extensive literature that may be said, in present terms, to study the processes by which institutions form, change and evolve, and thus gradually or suddenly change the type ("species") of their interactors. For present purposes, the most important examples include Hayek (1967), who studies spontaneous evolution of institutions ("rules of conduct") by anonymous individual innovations and selective widespread imitation; Vanbers (1992), who enriches Hayek's study by including collective innovations, resulting from an organized political process; and more recently North (2005) and Eggertsson (2005), who offer explanations why the evolution of institutions may often arrive at, and for a long time remain locked on, imperfect states.

But much remains to be done also in this direction. Most of the literature that deals with "phylogenic" institutional changes continues to be preoccupied with the effects of institutions on incentives, and says little about their more specifically "ontogenic" effects on the development of enterprises, industries, and technologies. By imposing on it the task to study also these effects, SGD helps it to interconnect with the evolutionary economics following Schumpeter, Nelson and Winter. For the institutional and evolutionary economists who seek contacts with each other, SGD thus acts as a double catalyst: it helps to interconnect their fields in general, and then, within the field of evolutionary economics, to interconnect the studies of the evolution of institutions with those of the evolution (development) of industries and economies (Pelikan, 2003c).

9 How Sufficiently General Darwinism May Help Social Scientists

In addition to the help with different inter-field connections, there are several ways in which students of economies and societies may find SGD useful. But, depending on their questions, their methods of analysis, and their broadness of mind, different students may find it useful in different ways, and some may not find it useful at all. The purpose of this last section is to illustrate its possible usefulness by briefly indicating how it may help to deal with four longstanding yet still largely open issues: group selection, economic development, reform policies and multiculturalism.

The issue of group selection is intimately connected with the one of units of selection. As noted at the end of Section 5, such units may only be parts of the instruction bases of successful interactors – but not the interactors themselves. These are only the units of testing through which instruction bases demonstrate their abilities to instruct.. It is the bases that bear the ultimate responsibility for the performance of their interactors, including the uses of the inputs that the interactors can receive and/or themselves extract from environments. Thus, while the performance of interactors is crucial, it is their instruction bases, or parts of these, that, depending on this performance, are selected or rejected.

That interactors are indeed unsuitable as units of selection can also be seen by considering that they may keep changing in many ways – such as by growing, developing, adapting, and replacing their agents – while any reasonable units of selection must be able to remain stable over long periods of time. Among the reasonable candidates, it is indeed only the instructions bases that may have this ability: they may stay put while their interactors change, and their copies may guide other similar agents in similar environments to form, possibly again and again, similar interactors.

The implications for the group selection issue are straightforward. Groups are interactors, and cannot therefore be units of selection. What their evolution may select or reject, according to their successes or failures, are the instructions that guide their members, many of whom may be entering or exiting, to self-organize and operate in them with such ultimate good or bad outcomes.

To answer the issue, however, it is also important to determine where the crucial instructions are located. In groups that are pure extended phenotypes with only one low level of instruction bases – such as ant societies, where all the relevant instructions are genomic –

they are parts of these bases. To be selected, they must be able to instruct the smallest agents to form the group's individual members in such a way that these are not only "fit" individually, but also socially. Thanks to these instructions, the individuals must be endowed with what may be called "inborn" or "instinctive" social behaviors that lead, in usual environments, to the forming of a successful group of a certain "species.".

But for social scientists, obviously, the most interesting are groups of humans. As noted, the human genomes do not specify human social behaviors, nor the form of human groups. Instead, they endow humans with the abilities to learn a variety of alternative social behaviors, and thus make humans depend on institutions as instruction bases of some higher level(s), to know which alternative, out of this variety, actually to adopt and learn. This implies that human group selection is mainly about the selection of institutions, for the main responsibility for how human groups form and perform is theirs.

Note, however, that this does liberate the human genomes from all selective pressures. While not directly responsible for actual social behaviors, they are responsible for the variety of behaviors that their bearers might possibly learn. This responsibility becomes critical if the success of a group requires institutions that do not belong to this variety – for instance, if they need behaviors that are more altruistic, or more individualistic, than what their bearers prove able to learn.

Concerning the issue of economic development, SGD may possibly offer some help to the growing number of development economists who no longer limit attention to quantities of resources, including the recent extensions to education and technological know-how, but recognize, in agreement with the new institutional economics following North (1990), that "institutions matter." SGD makes it clear that institutions matter even more than what this economics may imply. It brings to light, in addition to their usually studied effects on transaction costs and other incentives, their crucial effects of the "ontogenic" self-organizing of economies – in particular the internal experimenting with innovations and enterprises, including the selection processes by which individual talents are recognized, developed and put to efficient social uses, or on the contrary hindered and wasted.

SGD may also clarify how the responsibility for economic development is divided between institutions and the traditionally considered quantities of resources. It implies that institutions determine a maximum development potential that a lack of resources may leave unfulfilled, but that no surplus of resources can exceed – much like a lack of nutrition may prevent a mouse embryo from developing, but no matter how much nutrition this might be given, its mouse genome will prevent it from ever growing into an elephant. In consequence, when a poor economy has obtained the quantities of resources for realizing its actual development potential, the main obstacles to its further development must be sought in its formal and informal institutions.

This directly leads to the issue of reform policies. If the institutions of an economy hinder its development, the two obvious questions are: (1) Which institutions would do better? (2) How to reform (transform) the actual institutions into better ones? The debate of these questions has a long history, usually gaining in intensity after each deep crisis for which institutions may be suspected to be responsible, but is still far from definitely settled.[18]

How SGD may help with these questions was indicated in some of my earlier studies. Although SGD was not yet there explicitly presented, its main principles were already used. Concerning question (1), the attention to the "ontogenic" effect of institutions on development processes made it possible to disclose some previously hidden merits and demerits of different institutions. A simple comparison of their double effects on the generation of entrepreneurial trials and on the correction of the committed errors made it possible to show that suitably formed institutions of private property rights, freedom of enterprise and market competition have a much higher development potential than all forms of socialism and also capitalism with selective industrial policies – simply because they allow and encourage a higher variety of such trials and enforce a faster and more precise correction of errors (Pelikan, 1988, 1992).

This help with question (1) is also help with question (2): for reforming the actual institutions into better ones, these must be known, at least roughly, in order to set the reform in the right direction. But it must also be decided how fast and in how large steps to proceed. On this, there has been much disagreement, as documented by the heated gradualism vs. shock therapy controversy. SGD appears able to settle some of this disagreement by clearly distinguishing (i) changes of formal institutions, (ii) changes of informal institutions, and (iii) changes of firms, markets and industries. While no reform can directly control changes (ii) and (iii), which cannot but take time, this is no reason for slowing down changes (i) that the reform can control. On the contrary, it can be shown that dividing the needed institutional changes in several small steps is likely to make things worse by complicating and confusing the learning of the new institutions by the economy's agents (Pelikan, 1992).

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[18] During the last two decades, most of practical policy-making has been following the principles of so-called "Washington Consensus," including institutional suport for private enterprise, market competition, and fiscal discipline. More recently, however, these principles have been increasingly challenged, while economic theories have not yet provided fully compelling arguments for one side or the other. Somewhat surprisingly, institutional economists do not seem very interested in producing such arguments. Both North (2005) and Eggertsson (2005), in some of the most important recent contributions to new institutional economics, leave question (1) largely aside, and focus on obstacles that make institutional reforms difficult and imperfect.

Another possible help of SGD concerns the assessment of reform policies over time. This has also been subject to much disagreement, as even the reforms set in the right direction often started with alarmingly poor results. A simple dynamic comparison of the working of selection processes on markets and within government could offer a solution to the puzzle of why government-driven development may start well, but is likely to end up in a structural crisis, as happened in the beginning of the 1990's in Japan and South Korea, while market reforms typically follow the famous J-curve and start with a negative growth, but in the long run lastingly improve economic performance, as has happened in Central and Eastern Europe (Pelikan, 1999, 2007).

What leads from reforms to multiculturalism is that informal institutions are parts of culturally evolved norms and custom, which are difficult to influence by policies (cf. North 1990, 2005). Through their impact on informal instutions, cultures thus influence economic development in two ways: as key factors of actual economic performance, and as constraints on the extent and the speed of feasible reforms. As different cultures may exert substantially different influences on both, in relation to economic development, not all cultures can be accorded the same value. On the other hand, however, it must be recognized that valuable ingredients can be found in all of them. No culture can therefore be entirely rejected because of its possible ingredients with negative effects on economic development.

The help that SGD may offer is simply to bring to light, and indicate how to take into account, the basic fact that all human cultures may have parts that are economically relevant, with positive or negative effects on economic performance and development, and parts that are economically neutral, but possibly valuable according to other, non-economic criteria. As much confusion and unnecessary disagreements about the entire multiculturalism issue has been caused by leaving this fact aside, bringing it to light may indeed have merit.

Perhaps the clearest way to state this fact is by contrasting informal institutions with memes (cf. Section 7). A culture may indeed be visualized as a large and heterogeneous collection of memes, which all replicate from mind to mind across a given economy, and of which only a subset are informal institutions, instructing the specific forming and functioning of this economy. The economically neutral part of the culture can then be understood as the complementary subset, possibly denoted as "ornamental memes."[19]

[19] Some readers may find it interesting to compare a society's culture to the entire genome of a multicellular organism, and its economically neutral parts to the DNA-segments that do nothing else than replicate, often termed "junk" or "nonsense." Emphatically, these terms do not imply any negative valuation, and especially not for their socioeconomic counterparts: a society is more than its economy, and its "ornamental memes" may be highly valuable for other than economic reasons – e.g., esthetic, artistic, or religious.

Well-known examples of informal institutions are the forms and degrees of respects for property rights, fairness, business ethics, corruption, truth, and trust; while ornamental memes may be exemplified by traditional songs, dances, costumes, food, and religious rituals. A problem is, of course, that the dividing line between the two may not always be entirely clear. Some memes that may at first appear purely ornamental may turn out to have significant effect on economic behaviors, and must therefore be reclassified as informal institutions. For instance, different food diets may differently influence health and longevity, and different religious rituals may differently help or disrupt production. Where precisely to draw this line is therefore an open question that may require extensive research to be properly answered.[20]

But independently of the precise position of this line, a simple recognition that it exists may suffice to settle many disagreements between the advocates and the opponents of multiculturalism. When this line is taken into account, it appears easy to obtain a widespread support for both extensive multiculturalism concerning ornamental memes, and its severe limitations concerning informal institutions.

An interesting implication concerns the assessment of the consequences for a rich country of immigration from a poor country. This is that in addition to the usually considered benefits from additional supply of labor, the assessment must also take into account the effects on the rich country's institutions – for it is largely thanks to them that it has become rich in the first place (although many of its inhabitants may still be unaware of it).. The difficult question than is, by what civilized policies to protect the economically relevant features of these institutions, if some immigrants from a poor country turn out to carry with them some of the informal institutions that are among the major causes of this poverty – such as low respect for private property, rules of honor that foster wasteful conflicts rather than efficient competition, soft constraints on unethical business practices, and hard constraints on education opportunities for women, which both waste their talents and lower the quality of education of their children.

It is with these brief outlines that only roughly indicate how SGD may possibly help to deal with some important socioeconomic issues, but without finding any real answers to them, that the paper must end. The question of whether or not SGD may effectively help to find some of the real answers must be left to future research.

[20] Continuing the comparison from fn. 21, it may be noted that the borderline between instructing and non-instructing parts of genomes is also partly unclear, as many non-genic DNA segments, first believed to be "nonsense" were later discovered to play important instructing roles, and such discoveries are likely to continue.

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