REDUCTIONISM IN BIOLOGY AND IN THE SOCIAL SCIENCES

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THE CHANGE OF THE CONCEPT OF REDUCTION IN BIOLOGY AND IN THE SOCIAL SCIENCES

1. Holism versus Reductionism or The Rise and Fall of Reductionism

Traditional holists in biology and sociology (Driesch, Wertheimer, Köhler, and Durkheim) and modern system theorists (Bertalanffy, Miller in biology; Ackoff, Rapoport, Simon in economics; Parsons in social sciences; Heisenberg, Bell in physics and finally Leinfellner[1], Laszlo, Philips, Radnitzky, Ruse in philosophy) share a strong opposition to the reductionist's tendency to explain the whole solely in terms of its parts. The downfall of the deductive materialistic reductionism of the received view of reduction (Hempel and Oppenheim, Kemeny, Nagel) and the step by step demolition of the methodology of reductionism by Kuhn, Feyerabend, Sklar, Schaffner, Causey, Nickles and Wimsatt has led to a recent upsurge of antireductionism and finally to the abandonment of the idea that we reduce one theory to another (Hull and Wimsatt). It has resulted in a deep scepticism of any kind of reductionism, based on one-sided materialistic and analytic decomposition of wholes into parts. The whole idea of understanding and explaining holistic systems solely by the properties of the parts has suddenly become a dead end for research and scientific progress.

Holists have always attacked what Watkins[2] (1965) has called "methodological individualism" or materialistic atomism of the reductionists. It is exactly the materialistic search for ultimate particles or atoms in physics, for basic genetic units (genes) in biology and the foundation of societies on the individuals in the social sciences. In all cases the physical properties of the basic units build up the physico-chemical compounds, the biological, the economic, social and cultural systems. In Watkin's words, reductionism means to reduce our world to the ultimate constituents of the physical world, to the impenetrable last particles which only obey

simple mechanical laws. According to the reductionists, complex holistic systems

are solely the result of a particular configuration of the properties of its individuals,

of their dispositions, beliefs, etc., e.g., in sociobiology evolution of genes (lower

level) should explain and determine the evolution of culture (higher level). Thus

the backbone of the methodological individualism was reductionism, and its

feasibility in all sciences had to justify its tenets and goals. The early

deductive reductionists demanded indeed, that the dispute between "mechanistic" and

"vitalistic" should be reformulated as the question whether biology could be reduced

to physics (Oppenheim, Kemeny)[3], also the question, as to whether there are emergent

properties constituting the upper level organisms, was for Nagel[4] "just a matter of

reduction." Reductionists used for their support the dynamic growth of theories, the

fact that many theories included other theories has been interpreted as the claim that

theories are reducible to their predecessor-theories, such as Relativistic Mechanics

to Mechanics, Quantum Biology to Quantum Chemistry, Quantum Chemistry to Quantum

Mechanics, Collective Choice Theory to Individual Choice Theory, Darwin's Theory and

Mendel's Phenotypical Laws of Inheritance to Molecular Biology (hence to the Evolution

of Genes, Dawkins, 1976)[5].

Once scientific growth was interpreted as reduction, reductionism seemed to

be the methodology of scientific progress (Nickles, 1978)[6] which could enable the

unification of theories by explaining and even replacing higher level laws by lower

level laws. According to reductionists this method would permit the reducing of

higher level laws, L_2 to the lower level laws, L_1 of the reducing theory, T_1. But

the question remained unanswered as to what the real nature of the assumed reduction

relation was. Further, it remained open whether we had actually reduced one theory to

another $(T_2 \rightarrow T_1)$ or merely compared similar, partial structures of T_2 and T_1. It was

no wonder that it was proven very early by Sklar, Schaffner, Causey, Nickels, Day,

that the reduction relation was no simple, deductive relation at all. Rather it turned

out to be a "comparing" relation, e.g., the so called intralevel reduction (Wimsatt, 1976, 1976a, 1978, 1980) is in reality an iterated analogy or pattern-matching process and the interlevel reduction (Darden, Maull, 1977) ceased to hold between different theories. These changes in the meaning of reduction, together with the newest developments of holism in biology, force us to rethink and possibly to replace the whole method of reduction as well as its materialistic program by a new method of structural comparisons and step by step unification of two theories describing different levels of the same holistic system.

2. The Recent Development of Holism

But not only reductionism changed; holism changed too, partly under the reductionists attacks, partly because of the revolutionary holistic development of physics and biology in the last decades. The traditional philosophical form of holism stated simply that; (1) The whole is more than the sum of its parts. (2) The parts cannot be understood in isolation from the whole, because they will lose their holistic interrelations and (3) The whole determines the parts. When applied in biology it created the organicistic dynamic view (Haldane, 1926)[7] by incorporating principles of evolution (selection) and the mutual (causal) interdependency of evolving systems with the environment. Finally, under the influence of molecular biology, population genetics and system theory, holistic systems came to be viewed as dynamic systems which one can only adequately describe by models, provided that; (1) the evolutionary dynamics of a system S can be formulated in terms of time dependent differential equations of Haldane-Fisher type or of non-linear Eigen-Schuster type, (Leinfellner, 1983, 1984)[8]. (2) The system is open, exchanging matter and energy with the environment. (3) The evolving systems stay away from the deadlock of an internal equilibrium, and (4) the systems are order preserving and replicable.

Finally, the most astonishing and recent version of a global holism culminated in

Bell's theorem (Leinfellner, 1980)[9] Primas (This volume, p...). It is a general consequence of quantum mechanics and states, expressed in a simple form, that all systems interact with all other systems in a non-local, statistically causal sense. It introduces a panholism,based on statistical mutual-causality and interaction of all subsystems, systems, environmental systems, (Leinfellner, 1984) into our universe and rejects the existence of truly isolated and independent units in nature. It puts a final end to the materialistic search for ultimate units whose properties and laws would explain all the higher complex holistic systems.

Thus, modern dynamic holism rests on three formidable assumptions; (1) on Bell's theorem, which assumes throughgoing statistical and fluctuating causal interactions between all systems, (2) on the ontological assumption that higher and complex (living) systems repeat in their specific construction the simple hierarchical global order of lower levels (it is some kind of generalizaiton of Baer's law), and (3) on the assumption of a (biological) evolution of hierarchical levels. The presently known hierarchical global order consists so far of the energy level, the elementary particle level, the atomic level, the molecular level, the level of living macromolecules, the cell level, the multicellular level, the level of intelligent individuals and finally the social-cultural level.

3. What Happened with Reduction, or The Changes of the Meaning of Reduction for Holistic Systems

1) Downward directed reduction (the received view) changed to a "mutual reduction," i.e. to a structural comparision between different levels, with the goal to unify theories (T_1) or models (M_1) of the lower level with theories (T_2) or models (M_2) of the higher level. 2) It is obvious that the first victim of new holism and of system theory was the ontological reduction which wanted to reduce higher levels of holistic systems to lower ones (see sections 4-8). Inspite of Schaffner's (1974) and Sklar's (1967) criticism of ontological reduction, there exists still the common view amongst

reductionists and scientists that any methodological form of reduction (e.g., theoretical, intertheoretical, or interlevel reduction) is simply nothing else than a formal, mathematical or even a logical representation of an ontological reduction, i.e. an elimination of the higher level. Finally, the ontological reduction view would lead to the wrong conclusion that both the scientific progress and the unification of sciences could be achieved only by "reducing" higher levels to lower levels. If that were true, then ontological reduction would be just a hidden materialistic reduction of the early logical empiricism. But, in spite of the fact that reduction changed its meaning to correlation and comparison of structures at different levels to build a new theory, structural comparison remained a structural or functional mutual explanation of higher level models by lower level models, or vice-versa, explanation of lower level structures (models) by higher level structures (laws). Finally, ontological reduction has always been identified with a bottom-top directed causation, in the sense that the lower level systems determine in a causal way, the upper level systems. This is untenable, because the mutual statistical causation between the two levels (Leinfellner, 1984) forbids simply one-sided bottom-top deterministic causation as well as one-sided (100%) top-bottom causation, (see section 3). 3. To understand fully this change in the meaning of reduction for holistic biological and social systems we have to regard the unification of two isolated theories or models (T_1 or M_2 and T_2 and M_2) to a new theory T_3 as a temporal evolutionary process which consists basically of three steps; 1. The theory T_1 (or M_1) is modified ($\approx$) by a scientist to a theory or Model T_1^* (M_1^*) 2. the initial theory T_2 (or M_2) is modified too, or changed to T_2^* (or M_2^*) with the purpose to make out of the two isolated theories or models, describing different levels of one and the same holistic system, one new theory T_3 (or model M_3).

Thus the whole process is a heuristic or inventive process to explain the complicated interactions of holistic multilevel systems. We assume that the domain D_2

of the theory T_2 and the domain of the theory T_1, D_1 at least overlap, i.e. D_1 and D_1 have a common intersection: $(D_1 \cap D_2)$. In the following diagram, where modifying is symbolized by the matching relation " $\approx$ " and comparing or correlating by the " $\rightleftharpoons$ " relation, we get the following scheme for this unification method or trend:

$$
\begin{array}{lll}
\text{Upper level} & T_2 \; (M_2) & \approx \\
\text{Lower Level of a holistic system} & T_1 \; (M_1) & \approx
\end{array}
\left.
\begin{array}{c}
\boxed{
\begin{array}{c}
T_2 \; (M_2^*) \\
\;\;{}^* \!\rightleftharpoons\!{}_* \\
T_1^* \; (M_1^*)
\end{array}
}
\end{array}
\right\}
T_3 \; (M_3)
$$

Schaffner (1974) and Wimsatt (1976, 1978, 1980) proved that this method is iterable and is in fact a method which explains how biological and social theories grow and merge to a new one, but they forgot that this method only works, if the theories under investigation describe the same holistic system. Since it is the first task of the biological and the social sciences to explore the complicated interactions of living and social holistic systems this method is certainly a valuable new tool to build up and develop new theories to understand holistic systems. How this can be done will be explained with the aid of some examples.

4. Can We Reduce Economics to a Psychological Theory?

Often it has been said that the market is nothing else than the behavior of individuals explained by psychological laws. This looks like a complete reduction of a higher level collective behavior M_2 to a lower level individual behavior M_1. We know that individual preference behavior is dictated by maximization of the individual's utility: $M_1 = v(i) \geqslant 0$, but this alone cannot explain, for example, the demand and supply behavior of individuals at the market. But, we may try to find out under which conditions (constraints) we can modify M_1, the individual preference behavior, to M_1^*, the psychologically-based behavior of diminishing marginal utility. For that rea= son we have to find a property which the "private" individual at the lower level shares with its higher level "holistic" market behavior, the demand and supply structure of the market $(=M_2^*)$. Thus, under the modifying condition or constraint (C_1=consumption of successive units of goods by a single individual), we get the modification M_1^* of

the individual's preference pattern M_1. For an empirical example of M_1^* we watch

an individual drinking his morning coffee and we will observe that, if the individual's

need for more coffee is satisfied, his utility (preference) for the next cups will

drop rapidly. By generalization we get our Model M_1^* of diminishing marginal utility.

If we regard now the individual not as an isolated person drinking coffee, but

as a participant in the market (at the higher level) we will see that he maintains this

robust individual property (M_1^*) on the market. But, we actually regard now solely

the demand and supply behavior of the participants on the market (given a fixed income

of the participants) and forget about competition, cooperation and all the other

factors which determine simultaneously the market. Thus M_2^* is only a partial model

or aspect of microeconomics $(M_2^* \subset M_2)$. This partial model expresses the fact that

the quantity demanded varies inversely in relation to its price. M_2^* matches ideally

with our individual model of marginal utility (M_1^*) in the sense of a mutual reduction,

$M_2^* \rightleftharpoons M_1^*$. But, did we really, as Rothbard assumed, reduce the whole higher level market

behavior to the psychological, lower level individual behavior? or economics to

psychology? Certainly not. But what did we do? We simply picked out a salient and

robust individual preference behavior under the condition (constraint) $C_1 =$ marginal

utility M_1^* and found that the same behavior appears in the model M_2^* as the law of

supply and demand on the higher level. Thus, we did not reduce microeconomics to

psychology but showed that there is a same salient, robust behavior (structure) of

individuals on both levels if the holistic system: the market is activiated. Careful

analysis of this example shows clearly that we cannot regard it as an example of

reduction of economics to psychology. It tells us: 1) under which condition (constraints)

an individual's preference behavior resembles its market behavior. 2) it explains to

us how we have to modify individual behavior (M_1) to M_1^*, when we want to integrate

individual behavior into the holistic system. which we call a market.

5. Holism Revisited, or the Irreducibility of Holistic Properties

The problem of whether a class or group of our society is a holistic reducible system or just a reducible aggregation of individuals touches the central issues of holism: is a whole more than the sum of its parts? Reductionists would try to reduce holistic properties, whereas antireductionists would try to prove that holistic properties are irreducible and irreplaceable by lower level properties. We will bring a proof for the latter position in the following example, which we take again from social science: Decision theory distinguishes between individual decision making (M_1) and group decision making (M_2). Individual competitive decision making is defined by a set of strategies, (sequences of actions or decisions): St_1, $St_2,...,St_n$. There is for each decision maker an evaluation (utility U) of its strategies; U_1, $U_2,...,U_n$. There are, of course, the rules of the decision process, which describe the permitted moves or sequences of moves. Winning, (the solution of a decision process), against the other individuals, where each individual chooses his own strategies, means maximizing one's own utility $u(i) \geqslant 0$, by choosing one of the permitted optimal strategies or an optimal mixture of them, following the well-known minimax compromise. Here each individual follows his inherited individual instinct of maximizing his utility in an optimal sense, given full insight into the other's moves.

Now consider the cooperative "holistic" version of decision making, M_2, either in an economic or in a social or political scenario. Here the individual has to adopt a modifying subsidiary condition (constraints) namely, group rationality, expressed by the superadditivity of group formation; $C = v(i) + v(i) < v(i \cup j)$; which means that the group utility (utility of the whole) $v(i \cup j)$ should always be greater than the sum of the individual utilities which the individuals can gain alone as isolated individuals. It is clear that we cannot reduce the superadditivity of the whole, of the group formation because if we were to do so the group utility for individuals would become zero, for the limiting case $v(i) + v(j) = v(i \cup j)$. Such a condition would never create cooperation, and no wholes or groups would form in reality and in experimental

games. Thus we may use for a workable cooperative union, group, class or holistic behavior the mathematical condition $C = v(i) + v(j) < v(i \cup j)$, which represents mathematically the traditional slogan, "the whole is more than the sum of the parts." It expresses the oldest social principle; "United we are stronger ", and explains even the historical formation of hordes, great families, clans, i.e. primitive social holistic systems. This condition is clearly irreducible. Because, if the greater sign changes to the equivalent sign, then group formation stops automatically. On the other side, in experimental games, done at the University of Nebraska-Lincoln, it took an average of five to ten games until the individual gave up his noncooperative, lower-level individual behavior and adopted, i.e., learned, the higher level group behavior. A winning group is exactly a complex holistic system as already described, which perpetuates itself, ceteris paribus, of course in iterated sequential games. This example tells us clearly that reduction of group behavior to "single individual behavior" does not work. It shows clearly that the individual utility behavior (M_1) changes by adopting the superadditivity constraint or condition C_1 to a cooperative "emergent" behavior of the individual as a member of a whole, expressed by the model M_1^* which matches with group behavior; M_2, thus we get $M_1 \approx M_1^* \leftrightharpoons M_2$. Here we cannot at all reduce the holistic dynamic group behavior to individual behavior, but we can again show under which subsidiary conditions or constraints C_1 the individuals become cooperative.

The superadditivity principle has been widely applied even for explaining holistic cooperation of DNA molecules with proteins (Eigen, Schuster, 1978), or for holistic cooperation between animals and finally for evolution of intelligence (Leinfellner, 1984, 1983). Recently, Rapoport has given additional starting conditions for the transition of competitive single individual behavior to cooperative holistic group behavior. We see clearly that reduction in the old sense is a redundant operation if we deal with real holistic systems. Nothing hinders us from defining superadditivity as an "emergent"

holistic property in the transition from model M_1 to M_2 via M_1^*. (Holistic emergence is, of course, no (neo)-vitalistic concept).

5. Did We Lose the Meaning of Reduction by a Symmetrical Reduction Relation?

Looking back at the reductionism-antireductionism controversy we find that; (1) the unidirectional ontological reduction of higher to lower level systems has lost its meaning in biology and social sciences and (2) intratheoretical reduction (called "transformatory" reduction by Nickles (1973), or "successional" reduction by Wimsatt (1974), which should reduce a (historically) following theory T_2 (e.g., Relativity Theory) to a predesessor Theory T_1 (Mechanics), if the subsidiary conditions permit it, is actually a comparison and merging of two robust partial structures (or partial models) of one theory T_2 (M_2) with a partial structure of another theory $T_1(M_1)$, given the same Domain $D_1=D_2$ of application or at least a common intersection of the domains $(D_1 \cap D_2)$ in a unified third theory T_3 (M_3).

For such a partial comparison of structures we neither need Nagel's criterion, that T_1 is logically derivable form T_2, nor is it a hindrance if the two theories or their partial models M_1 and M_2 are incompatible (Kuhn, Feyerabend). For a better understanding we give a more detailed discussion of the so-called reduction of Special Relativity Theory to Classical Mechanics. We find immediately that only a part of the Special Relativity Theory, the impulse model=M_2 defined by $_{df}m_o v/\sqrt{1-v^2/c^2}$, over a certain domain of application D_2 can be modified, for the sake of structural comparison to: $M_2^* = {}_{df}m_o v/\sqrt{1-v^2/c^2}$ plus the subsidiary conditions or constraint, $C =$ v approaches 0, or $v \to 0$. We get the classical impulse model $M_1 = mv$, when the domain of D_2 shrinks to D_2^* and the limit case of this shrinking or matching is the model M_1. This so called reduction has the form $M_2 \approx M_2^* = M_1$ and the alleged typical reduction relation which should be asymmetrical according to the received view of reduction is the identity relation! In this and many cases the "reduction" relation is symmetrical, since $M_1 \leftrightarrows M_2^*$ and $M_2^* \leftrightarrows M_1$ are equivalent, and $D_1 c D_2^* c D_2$. Thus the identity relation , as in most cases, turns out to

be a special case of an approximative comparison of partial structures between two theories T_1 and T_2 or between two models. But, why should we call it a reduction since we have lost its original asymmetric meaning?

6. Can We "Reduce" Collective Choice Theory (M_2) to Individual Choice Theory (M_1)?

It is widely believed that collective behavior can be reduced to individual behavior, but if we try to reduce the model of collective choice (M_2) to the model of individual choice (M_1) we will see that this is impossible. If the structure of M_2 is given by $(OA)^C$ = collective order axioms, where $(OA^C) =_{df}$ (Axiom of Connexity & Axiom of Transitivity & Collective Choice Axioms) and M_2^* is obtained by adding the Arrow condition C_2 for democratic holistic systems, here: C_2 = (U & I & P & D), where U is the independence Axiom i.e. free choice amongst alternatives; I is Independence of irrelevant alternatives; P is Pareto-optimality, and D is non-dictatorship. What Arrow here actually imposed on the Collective Choice axioms (OA^C) is our basic idea of a free democracy. Practically he modified M_2 to $M_2^* = (OA^C$ & UPID). Now we should be able to amalgamate individual choices into collective ones and should be able to prove that the collective choices are reducible to, or are based on individual choices or preferences. It was one of the greatest surprises in collective choice theory, i.e. of models of our free democratic society, that this "reduction" generated an inconsistency by yielding the famous Arrow paradox $D \supset \bar{D}$ or D & $\bar{D}$, that means the flat contradiction that the model $M_2^* = (OA^C$ & UPID) is dictator free D and at the same time contains a dictator $\bar{D}$. "Dictator" is intended here in the general societal sense, that the individual choice P^1 (preference) is not free, contrary to Arrow's conditions, but dependent on someone else's choice. The impossibility of the reduction of collective choice to individual choice yielded the Arrow paradox[10] which has shaken collective choice theory in its foundations. Its consequences are: (1) collective choice theory cannot be reduced, (2) either M_2^* is inconsistent or our democratic society based on

the ideals of the French Revolution, Freedom (U,D), Equality (I), and Brotherhood (P),
(Arrow, 1966), cannot be theorized free of contradictions or (3) the society as a
whole possesses superior emmergent properties which the individuals do not possess.
Later D. Black tried to circumvent Arrow's paradox by the single peak condition, C_2^{**} =SP,
which for individual choices or preferences is a subsidiary "uniformity condition"
(constraint). It demands that in any society there should exist or should be introduced
a heritable, invariant, consistent underlying basic preference order for all individuals.
This underlying consistent order for all could be achieved, e.g. by education, etc.
Thus, we get a modification of M_2^* to $M_2^{**} =_{df} (OA^C)$ & UPID + (SP). If $M_1^{**} =_{df} (OA^i$ &
UPID & SP) holds, the Arrow paradox disappears, i.e. our societal model becomes
contradiction free and the "dictator" vanishes. Of course, D. Black's condition C_2^{**}
introduced the idea of an "ought" a uniformity of preferences for all individuals
to match their preferences with the collective preferences and consequently under this
strong constraints the upper level model M_2^{**} becomes comparable with the lower level
model M_1^{**}, thus forms a contradictory free model M_3 of collective choice.

There have been other modifications, one of them is Skala's modification, SM
(Skala, 1978)[11]. Skala modified M_2^* to M_2^{***}, by letting increase the number n of the
members of the society. With this utopian, but not unrealistic condition: n → oo, the
contradiction and the dictator vanish again.

This example shows clearly that we cannot reduce collective choice theory to individual
choice theory, except by introducing voluntarily imposed constraints or uniformity-
conditions such as Black or Skala's condition on the individual's prefernce patterns.
Thus we get the iteration model·

$$
\begin{array}{ccccccc}
M_2 & \approx & M_2^* & \approx & \boxed{\begin{array}{c} M_2^{**} \\ \Big\updownarrow \\ M_1^{**} \end{array}} & \approx & \boxed{\begin{array}{c} M_2^{***} \\ \Big\updownarrow \\ M_1^{***} \end{array}} \\
M_1 & \approx & M_1 & \approx & & &
\end{array}
$$

which shows very clearly how incompatible theories or models M_1, M_2 and M_1^*, M_2^* can be modi
fied   to compatible new theories or models, the two and three starred ones. Here   again
we have lost completely the idea of a rigid reduction as it was defined by the received view.

7. Can Life be Reduced to Physics ?

In this section we will analyse a case of a so-called reduction of a primitive biological model, M^B of self-replicating RNA strands, of Eigen-Schuster type, to Thermodynamics, M^{Th}. M^B will refer to the sensational discovery by Cech (1984) of a highly unusual type of a single-stranded RNA. The findings support Eigen and Schuster's idea that single strand RNA, rather than double strand DNA may have been the most important carrier of genetic information as life began on this planet. This type of single strand RNA lives inside a creature, called <u>Tetrahymena</u>, a single cell organism found in pond water. This Tetrahymena type of an RNA strand is able to rearrange its internal structure by cleaving itself at specific locations and then joining the fragments in a specific new sequence, in other words, this newly discovered DNA can replicate itself "parthogenetically," without the help of proteins and enzymes and can thus altering its genetic informations (Cech, 1984). This example should demonstrate the heuristic .non reductive character of this new method which replaced reduction in this field.

If we compare the model M^B with the M^{Th} model, or a model of life in its simplest form, M^B, with the thermodynamic model, we see immediately that they are incompatible. The most imcompatible, widely known dissimilarities are; (1) the law of entropy, governing thermodynamics M^{Th}, and (2) the concept of a thermodynamic equilibrium. As Friedman already showed (Friedman, 1982)[12], the so-called heterogeneous reduction, "reducing wholes (ensembles) to individuals," does not work, since if the lower level macromolecules are subjected to the laws of thermodynamics, it does not follow that the holistic living system, our Tetrahymena-DNA will follow those laws.

Firstly, we have to be aware that an average cell is an enormously complex system, 1000 different enzymes, each existing in 100 exemplares, i.e. 100,000 enzyme molecules, each performing a particular job, regulating the metabolism and controling ca 10,000 chemical reactions (syntheses) per minute. Such a complex dynamic, self-replicating system cannot be "reduced" at all in a literal sense to simpler units, without losing its holistic order,because the higher level systems in M^B are order pre= serving.or negentropic,wheras the lower level inorganic systems are order

decreasing (entropic). Reduction and structural comparisons are impossible because
of the incompatibility of M^B and M^{Th}. But, if we compare modifications e.g., the
modified entropic and modified equilibrium models of M^B and M^{Th}, according to the scheme:

$$M^B \approx \left.\begin{array}{c} \boxed{\begin{array}{c} M^{B*} \\ \Updownarrow \\ M^{Th*} \end{array}} \end{array}\right\} \begin{array}{l} \text{New Model or Theory} \\ M_3 \; (T_3) \end{array}$$
$$M^{Th} \approx$$

we may find astonishing similarities ("$\rightleftharpoons$") between primitive life (M^B) and
thermodynamics M^{Th} within a new unified model M_3 (or theory T_3). Now, the structure
of thermodynamics (M^{Th}) can be informally described by (1) the conservation of its
energy, (2) the steady increase of the entropy of its equilibrium states, and (3) any
relaxation of the constraint on a system leading to an increase of entropy.

We want now to modify the model M^{Th} (or classical thermodynamics) to the model M^{Th*},
the famous Onsager-Prigonine model, Onsager (1931), which Prigonine (1962, 1982)
created exclusively for that purpose. It is the model (M^{Th*}) of non-linear thermodynamics
which uses suitable subsidiary conditions (constraints) for modifying M^{Th} to M^{Th*}.
This model is based on some invariance (or stability) conditions for the non-linear
differential equations, which describe the dynamics of the Onsager-Prigonine thermodynamic
systems $S \subset D^{Th*}$. Its lower level inorganic and lifeless systems can generate
spontaneously and sustain order, like upper-level systems, e.g., our Tetrahymena DNA,
if the following constraints hold (1) the dynamics of the systems, their behavior,
can be described in terms of the non-linear differential equations of thermodynamics
(of model M^{Th*}), (2) if the system is an open system, exchanging matter and energy with
the environment as living systems do, (3) if the system stays always far removed
from a state of internal equilibrium, (equilibrium modification), and (4) if autocatalytic
and cross-catalytic reactions with feedback occur (Friedman, 1982).

We know now from thermodynamics (from M^{Th}) that any final state, any equilibrium
state of lower-level systems must have a higher entropy than the initial ones. But,
such an increase of entropy would increase disorder, uniformity, and that would be

incompatible with the order preserving tendency of our upper level living Tetrahymena-RNA macromolecule of the model M^B. But, using Prigonine and Onsager's "subsidiary constraints" we can modify M^B to M^{B*}. Then, we are able to compare more successfully M^{B*} with M^{Th*}. But, when we modify the linear thermodynamic model M^{Th} to a non-linear thermodynamic model M^{Th*}, we have to preserve the most important robust property of entropy increase in both models. For such a purpose we use another constraint on the lower level and split up the total entropy S or dS of lower level systems, the entropy increase, into two parts: $dS = DS_i + dS_e$, where S_i is the internal entropy of the lower level system, and S_e the external entropy of the surrounding environment. Since the lower-level systems in D^{Th*} are open, it is evident that even an internal entropy decrease (equal to order increase) would not any longer violate the second law of thermodynamics, if it is compensated by an equal increase of the external entropy. Thus, the lifeless lower-level systems in D^{Th*} can even be "negentropic" order preserving, without violating the thermodynamic law of entropy! But, how can we change from classical thermodynamic equilibrium to non-equilibrium or disequilibrium? Quite generally, each strict equilibrium would be the deadlock, the death of any evolutionary process, the final stop and such a system would stay forever in this final state. Again, Onsagers and Prigonine's model will help us. It is well known, that for lower-level systems not far away from the internal equilibrium, the changes or deviations from the equilibrium are getting smaller and smaller, or the gradient, the rate of changes with respect to the distance, is approaching zero.

Now, all the changes consist of flows F of energy and heat (expressed by their gradients G), and since each flow F_i is mutually dependent on all the other flows F_j, we get for the total flows (changes) $F_{ij} = F_{ij}x_ix_j$. If the lower level system is near the inner equilibrium, then the external losses F_{ij} and internal gains F_{ji} are the same $F_{ij}=F_{ji}$. According to Onsager (1931a, b) we get some kind of an invariantly stable state of the dynamic internal process if dG/dt is a minimum or the internal

entropy production approaches a minimum, irrespective of the sum total of the enropy of the whole system: internal system and environment. Therefore, our inorganic lower-level systems in D^{Th*} may strive towards a steady state by increasing their order, just like any living upper level systems in D^B, e.g., our Tetrahymena- RNA

Since there are always disturbances, molecular fluctuations, Brownian molecular movements, random events, coming from the environment and the inner lower-level system, the steady state of the lower-level system near equilibrium will, if it oscillates symmetrically, stay steady near the equilibrium, but if disturbed in an asymmetrical sense it will leave its "near the equilibrium $state_1$" in favor of a new "near the equilibrium $state_2$." It all depends on two conditions. If the asymmetric disturbances or fluctuations disappear, the lower-level systems will stay stable, near the old equilibrium $state_1$, if the asymmetric disturbing fluctuation prevails, it will automatically change over to a new near the equilibrium $state_2$. That means, if it suddenly becomes unstable it will change from equilibrium $state_1$ to the new equilibrium $state_2$. If now the new, near the equilibrium $state_2$ has a smaller entropy production it has increased therefore, its internal order (organization).

In such a manner a higher-ordered inorganic state can be generated from an inorganic state of lower order and organization, provided (1) that the whole lower-level system is open, i.e. reacts like living systems with its environment, (2) that the lower-level system is far from the internal deadlock of an equilibrium and (3) that it possesses auto- and cross-catalytic reactions which again are necessary to create negentropy (Friedman, 1980, p. 32). Such systems will very quickly behave like biological mutants in great numbers, and the more stable and better adapted will survive. The modified extension of thermodynamics M^{Th} to a non-linear, non-equilibrium thermodynamics M^{Th*}, ($M^{TH} \rightleftharpoons M^{Th*}$) will permit the comparison with the modified model of M^B, M^{B*}.

To sum up, we get some interesting philosophical and ontological consequences:
(1) we cannot and do not reduce in biology any more life to inorganic, physical levels,

but compare solely salient "robust" common properties of higher and lower levels if they are interacting within living holistic systems, (2) ontology is not a description of a static exclusive hierarchy in which two different levels are completely seperated, it is rather a dynamic ontology of becoming and explaining the function of multilevel holistic systems (i.e. the ontological barriers break down only within living systems, but not in the sense of the materialistic reduction that the lower level replaces the higher level); (3) one can demonstrate how and under which conditions upper-level systems influence lower-level systems and why lower-level systems are weaker than upper-level systems. There is a strong similarity here with Prigonine's idea that even lower-level quantum physical operators are changed significantly in "living systems," by the addition of higher-level superoperators influencing the quantum physical operators "in vivo." (4) The whole process describes the formation of a new theory where former separated theories T^B (M^B), T^{Th} (M^{Th}) are modified and united in a new theory if they deal with the same holistic system.

8. Reduction of Culture to Genes? A Reduction Problem of Sociobiology.

There remains one open question with respect to the received view of reduction. Maybe reduction reveals that lower-level systems influence and control in a direct causal sense higher-level systems? Then, any reduction program would require finding the primary lower-level causes which effect and influence totally the higher-level systems. Lumsden and Wilson have indeed linked in a new causal way cultural evolution with genetic evolution in their recent books "Genes, Mind, and Culture" (1981)[13] and in "Promethean Fire" (1982). Many critics have regarded it as a causal reduction of cultural evolution to genetic evolution, or a genetic explanation of culture and mind, but as will be shown in this chapter, that is certainly not the case.

Lumsden and Wilson's Gene Culture Theory M^{GCT} has many forerunners, but their theory is certainly the best and most elegantly written work in this field.

Dawkins (1976), in his "selfish gene" theory tried to reduce radically in a causal sense, biological evolution as a whole to the evolution of genes. Maynard-Smith (1983) explained the evolution of social animal behavior and of inheritance of properties (acquired in an almost Lamarquian sense) by a game-theoretically based phenotype-genotype coevolution, which has been mathematized successfully in a new version of game theory, the theory of differential dynamic genes. Finally, Eigen and Schuster (1981) extended this idea to lower-levels. They could prove in a comparative sense that the historical evolution of DNA-strands, their struggle for survival and their cooperation with proteins (enzymes) can be explained by and integrated into the new theory of the dynamic differential games, which includes even cooperative game theory. A detailed analysis is given in Leinfellner (1983, 1984).

Lumsden and Wilson's two level gene-culture theory would, in a certain sense, link Popper's third world with its second, and its second with its first by a bottom-top causality. Of course, such a bottom-top causality would vindicate the materialistic received reduction program. Our analysis of the Gene Culture Coevolutionary theory will prove that this is not the case. For that purpose we have to give a short survey of the main concepts of the Gene Culture Coevolutionary theory M^{GCT} to understand the importance of Lumsden and Wilson's view. Firstly, we have to understand why Lumsden and Wilson modified what we usually understand under culture and under a traditional theory of culture M^{TC}. Our normal traditional theories of culture regard culture as the sum of all artifacts, behavior, institutions and mental concepts, transmitted solely by learning among the members of a society. Since this view of society is typically static, Lumsden and Wilson modified this static character to a dynamic, evolutionary one. Thus, we get a typical modification in the sense already discussed, $M_2 \approx M_2^*$. The next decisive modification (or constraint) used the model of epigenesis, i.e. the holistic-dynamic concept that evolution on the lower gene level and the higher cultural level is one process of interaction between the genes, culture and the environment =

gene culture (M^{CGT}), including the external and the cultural environment. Thus, gene evolution (level 1) ultimately causes the evolutionary generation of the distinct anatomic, neurophysiological, cognitive-behavioral, mental and relatively stable patterns in human cultures, (level 2). Epigenesis as a holistic process begins with the cells and stretches over the animalic, psychic and mental levels and expands until it includes all aspects of culture. But, how does the coevolution of lower-level genes and higher-level culture work? Do genes cause culture or does culture cause genes or are both equal partners? Firstly, M^{CGT} is a two level theory in an ontological and in a theoretical sense, and secondly its step-by-step construction in Wilson and Lumsden's fascinating book resembles more and more the enfolding unification of two theories of different levels into one.

The causal interaction of the two levels is introduced by the model of epigenetic rules M^{EP}. The next question is: What causal links exist between the genes and culture? This is done by the constraints of the model of epigenetic rules M^{EP} which show how culture depends on the DNA developmental blueprints, the genes. For a better understanding of the following we have to de-anthropomorphize the concept of a rule. An effective rule is simply a one-to-one, or a many-to-one (causal) function f, or a statistical one-many or many-many (causal) function, which regulates the interactions between genes G and culture C, in such a sense that for every gene $g_i \in$ G or group of genes, there exists a cultural trait, called culturegene $c_i \in$ C. The function has the simple form $g_i f c_i$. Much will depend on the empirical meaning of f and c. We don't need it for genes g_i, since there exists already an excellent bio= chemical interpretation of the genes, namely strands of DNA-molecules.

Epigenetic rules come in two versions: primary and secondary, epigenetic rules. Both channel, according to Wilson and Lumsden, create, and in a causal sense regulate culture. The primary rules regulate neurophysiological, statistically-invariant patterns of human behavior, which occur in all humans in the same invariant way;

e.g., they regulate the early life of individuals and they are cross-culturally invariant, such as invariant patterns of smell, color classifications, taste, (e.g. ideosyncrasies in all individuals). Secondary epigenetic ruels are causally responsible for higher cultural patterns, called culturegenes (c), such as patterns of probability evaluation under uncertainty, risk behavior, phobias, cognitive patterns, fashions, etc. They are, invariantly, i.e. in the same form, recuring patterns of cultural behavior. A set of culturegenes C consists of simple culturegenes c_i, $C = (c_1, c_2, \ldots c_n)$. The epigenetic rules (f in our simplified interpretation) connect each higher level culturegene c_i with one or more lower level genes g_j. For the sake of simplicity we take a simple one-to-one functional dependency, the strongest classical causal relation;

$$(g_1, g_2, \ldots, g_n) f(c_1, c_2, \ldots, c_m)$$

Interestingly, epigenetic rules resemble Freud's contributions from the unconsciousness and the culturegenes resemble somehow Jung's archetypes, which manifest themselves in invariantly occuring and recuring cultural, behavioral patterns, attitudes, artifacts and mentifacts in mythology, poesy, religion. The upper level set C is relatively homogeneous for a specific epigenetic rule f_i, and the $(c_i, c_2, \ldots c_m)$ form a polythetic set C_1 which means that the divergent members of the set C_1 show only family resemblances.

At this state of reconstruction Lumsden and Wilson's theory links the lower with the upper level by mapping the lower level model of gene evolution M^{GE} onto the higher level model of culture gene evolution M^{GCT} in the following way: for each change in the frequency of the genes within a gene population there is a corresponding change of the frequency of our culturegenes. If α, β, γ, are frequencies (in terms of probabilities), then cultural change is a change in the frequency distributions from C_1 to C_2.
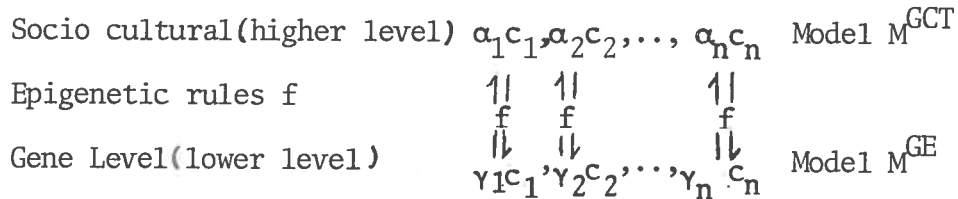
$$C_1 = \alpha_1 c_1, \alpha_2 c_2, \ldots, \alpha_n c_n \qquad : \qquad \alpha_1 + \alpha_2 +, \ldots, + \alpha_n = 1$$

If: $\alpha > \beta$ or $\beta > \alpha$

$$C_2 = \beta_1 c_1, \beta_2 c_2, \ldots, \beta_n c_n \qquad : \qquad \beta_1 + \beta_2 +, \ldots, + \beta_n = 1$$

The causal impact of the lower level M^{GE} on M^{GCT}, the higher level, is achieved by two subsidiary conditions (constraints) of the Gene Culture Coevolutionary theory (GCT)

namely: (1) that changes in the gene distribution have a causal effect on the culture
gene distribution and (2) vice-versa. If we have two levels we get an over-simplified
version of the causal interaction of the lower level M^{GE} with M^{GCT}, the higher level,
by the following scheme;

Socio cultural(higher level) $\alpha_1 c_1, \alpha_2 c_2, \ldots, \alpha_n c_n$ Model M^{GCT}

Epigenetic rules f

Gene Level(lower level) $\gamma_1 c_1', \gamma_2 c_2', \ldots, \gamma_n c_n$ Model M^{GE}

Once we have arrived at this point, we have to use Wilson and Lumsden's concept of
"translating." Translation is the causal effect of the epigenetic rules on the
evolution of individuals and their development of individual cultural patterns
(observed and measured by the usage-bias curves which display the probabilities α_i
that an individual (organism) will use one or the other of various culturegenes c_i,
given that it possesses a certain genotype and lives in a particular environment).
To establish a statistical correspondence of the theoretical terms (g_i) of the lower le=
vel model M^{GE} with the upper level model's (M^{GCT}) theoretical terms (c_i), the average
frequency of a gene (g_i) within the whole population is obtained from the ethnographic
curve, a sociometric concept of the higher level M^{GCT}. Ethnographic curves define
a cultural, statistically invariant pattern, i.e. a pattern which remains stable for
a relatively long time, but not forever. The ethnographic curves represent the pro-
portion of individuals in the society that possess one or the other culturegenes
as opposed to another distribution. It can be used as an ideal intrasocietal measure
to compare different culturallyinvariant patterns even in different cultures. Now,
Wilson and Lumsden can argue that the usage bias curve of any individual in a certain
culture gives the actual probability that this individual selects a given culture gene
c_i from the available pool of culturegenes C. Hence, given the usage bias curve for
each individual, the distribution of the culturegenes and the rate of gene-culture
coevolution can be determined. The matching of M^{GE} with M^{GCT} is achieved if the following

additional subsidiary conditions (constraints) are observed, taken of course, from lower-level population genetics: (1) if genes, or small portions of genes, or polygenetic groups really cause and control the impact of epigenetic rules on cultural, relatively stable patterns, the culturegenes (bottom-top causality), (2) If no uniform epigenetic rules exist, (3) if variations e.g. mutations in the epigenetic rules are inherited, i.e. the interactions between the two levels is of statistical causal nature, (4) if the epigenetic rules have a causal effect on the individual's cultural development of its cultural patterns (gene culture translation), and (5) if culture genes differentially effect the genetic fitness of the next generation by altering the frequencies of the culturegene distribution in a population and are thus able to influence the evolution of culture in a causal sense by the coevolution of the genes (top-bottom causality).

Without going into the formal and empirical details of the sociometric parts of the Gene Culture Coevolutionary theory (M^{GCT}) we may now summarize our results.
(1) The Gene Culture Coevolutionary theory (M^{GCT}) is obtained by a heuristic unification process, not by a reduction, of the following type: given the theory of gene evolution (M^{GE}) and given a statistical, perfect matching of lower-level gene evolution theory (M^{GE}) with the higher level gene culture evolutionary M^{GCT}, $(M^{GE} \leftrightarrows M^{GCT},)$ then the rectangles represent the synthesis, or the "modifying unification" of previously incompatible theories or models, which deal with the same holistic system, (here cultural and genetic evolution) to a new theory or model. Thus we get:

$$
\begin{array}{lll}
\text{Traditional} & & \text{Evolution} \\
\text{Theory of culture } M_2 \approx \left[M_2^* \right] & & \text{of culture } M_2^* = \left[M^{GCT} \right] \\
& & \quad \Updownarrow_* \quad \text{and: Evolution}_* \quad \Updownarrow \\
\text{Trad. Genetics} \quad M_1 \approx \left[M_1^* \right] & & \text{of Genes } M_1^* = \left[M^{GE} \right]
\end{array}
$$

New theory of coevolution of genes and culture

This scheme is a heuristic inductive or statistical method of inventing and modifying, f.i. incompatible theories of different levels having the same or similar domains (applications)

and describing one and the same holistic system to a new compatible theory. This method is by no means a reduction of culture to genetics, it rather correlates or matches two formerly incompatible theories or models to a new theory or model. Thus it is an unifying and integrating method which, since it is iterable, could merge and unify our knowledge by fusing theories (models) of different levels, dealing with the same holistic system, to more and more complexer units or supertheories.

(2) Since the Gene Culture Coevolutionary theory is an intrinsic statistical theory, it can only explain group or average behavior of individuals within a society, but never the exact cultural patterns of a single individual. Therefore, the concept of causality, used within M^{GCT}, is that of a statistical causality, (see Leinfellner, 1981, 1984)[14], where the concept of statistical causality in social sciences is discussed in more detail). Moreover, the transitional probabilities, for example, in cultural-pattern-changes and in changes of the ethnographic curves have to be Markovian. Therefore, since statistical causality and the nature of transitional probabilities do not permit classical deterministic causality and throughgoing transitivity of causal chains, we have to reject for M^{GCT} a deterministic bottom-top causality. Thus we have to assume for the whole of gene culture coevolution a partial, statistical, mutual causality of many-many type which permits only that many (weighted) partial causes effect many (weighted) partial effects. Therefore, between upper levels and lower levels there are only mutual, statistical causal relations (Leinfellner, 1981, 1984). This has the tremendous advantage that we are able to include into the partial causes the free will or the freedom of choice of a single individual becomes one of the partial causes which influence cultural patterns i.e. the ethnographic curves. Thus, there exists no "materialistic" deterministic causation from bottom to the top levels.

(3) Statistical causation has further the advantage that it permits the inclusion of Wimsatt's condition (in a weak form) into the higher level model M^{GCT}; it demands that given this mutual interaction of genes-culturegenes, the changes in the genes will

be caused with higher probability by the higher-level units, the culturegenes, thus we have a predominance of statistical top-bottom causality. Therefore, in the main extent, cultural coevolution can be influenced only by a lower probability by the lower level units (genes). This again makes it unlikely-- contrary to the spirit of Wilson and Lumsden's Gene Culture Coevolution theory-- that individual genes or small polygene groups have a direct deterministic effect on cultural levels of organization. But, higher levels of cultural evolution have a predominant evolutionary social, political and perhaps ethical autonomy and regulating influence. The predominance of the higher level units is only a statistical causation and its "statistical" autonomy should, of course, never violate fundamental basic chemico-physical conditions of existence and functioning of the lower level, for example, by polution, atomic genocide.

(4) Therefore, we agree, albeit cautiously, with Lumsden and Wilson that because of the mutual dependency of genes and cultural evolution genetic engineering could be used only as a therapeutical preventive measure as well as gene manipulations for creating better designs and patterns for better human societies. But, this again will depend solely on the upper level ethical standards and the upper level ethical evaluation of the research strategies used for genetic engineering and changes. But, we disagree that these changes could be done solely by bottom changes, i.e. changes in our hereditary genetic material.

(5) Given (1) and (4) we may better regard the interaction between genes and culturegenes as a sequence of gametheoretic, competitive and cooperative decision processes (see Leinfellner, 1984)[15]. This could be done without violating the basic conditions of the Gene Culture Coevolutionary theory.

The analysis and reconstruction of Lumsden and Wilson's Gene Culture evolutionary theory $M^{GCT} \leftrightharpoons M^{GE}$ makes it very unlikely that exact knowledge of the structure of individual genes (small strings of DNA) alone would be the decisive tool in sociocultural engineering programs as is expected by Wilson and Lumsden. But, the astonishing

result that higher levels of organization may have a greater evolutionary,statistical causal significance and impact than lower level units may lead to important social, political and ethical implications.

The analysiss of Wilsons and Lumsden's theory shows how our views of scientific theories have changes.Scientific theories are not any longer static but dynamic units. Since the method of modification and unification of former incompatible theories or models creates compatible supertheories or supermodels it is not any longer appro= piate to use the label "reduction" for such a unifying method.This evolutionary, self improving unification process is rather an innovative and interdisciplinary method. If it continues it has the enormeous future chance to unite heuristically scientific theories or models of different levels and different disciplines,if and only if they deal with the same holistic systems, to gigantic hierarchically ordered networks of theories or models.Its potential future lies in its possibility to connect and build up step by step a holistic rognitive network of theories or models about a world,provided that this world is ina global sense really a dynamic interwoven holistic system of cul= ture life and inorganic levels.

NOTES

1. Leinfellner, W., Leinfellner, E., Ontologie, System Theorie und Semantik.

2. Wattkins, "Historical Explanation," p. 504.

3. Oppenheim, Kemeny, "On Reduction," p. 7.

4. Nagel, "The Meaning of Reduction," p. 310.

5. Dawkins, "The Selfish Gene," 1976.

6. Nickles, "Two Concepts, " p. 180.

7. Haldane, The Science, pp. 74-75.

8. Leinfellner, Evolutionary Causality, pp. 260-262.

9. Leinfellner, Grundtypen, p. 129.

10. Arrow, K.J., Social Choice.

11. Skala, H.J., "Arrows Impossibility Theorem," p. 224.

12. Friedman, Intertheoretical Reduction, pp. 17-20.

13. Lumsden and Wilson, 1981, p. 119.

14. Leinfellner, 1982, 1984, pp. 233-246.

15. Leinfellner, 1984, p. 253.

16. Schank, J., Reduction in Biology (unpublished manuscript).

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