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Does The Future Depend on Which Discipline You Consult?

On much about the broad issues of sustainable development, developing world poverty, health, population, and environment, scientists differ. Is this just the inevitable differences in perspective and knowledge of individual scientists—as, no doubt, citizens assume. Or is it something more?

Inside the scientific community, it is no secret that scientists of different disciplines may interact, on issues that overlap their disciplines, like cats and dogs. Different disciplinary perspectives, time frames, contexts and methods obviously have much to do with the differences in conclusions.

Sociologists of science appear not to have investigated this issue much. But a distinguished demographer, Nathan Keyfitz, has found eight main axes of difference and in the article printed below has described why the policy conclusions of two or more scientific disciplines may often appear to contradict one another and gives thoughtful comments about six such areas.

Things get even more complicated when representatives of different disciplines interact in an interdisciplinary scientific organization like our own, or the National Academy of Science. In some cases, the pronouncements on broad issues may be decided in a *political* process in which, for example, different disciplines lobby their ruling council to determine, for example, what ought be said about the seriousness of population increases.

And in such political processes, just as in the political processes of a democracy, it is not just votes but also commitment (as in single-issue voters) that matters. One scientist may be commenting dispassionately about an issue while the other, steeped in commitment and indignation, sees the issue as one raising the most serious moral and ethical questions and one on which he or she is waging a world-wide *campaign* to ensure that something be said or not said.

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CONTRADICTIONS BETWEEN DISCIPLINES AND THEIR INFLUENCE ON PUBLIC POLICY

by Nathan Keyfitz

Why is it that throughout this century the most authoritative voices in science, and especially in the policy sciences, have called for interdisciplinary research, and yet relatively little takes place? One can only conclude that it is harder than appears, that some hidden obstacle stands in its way. There was no difficulty when interdisciplinary meant what it says, exploring the empty space between the recognized disciplines. Biochemistry is an instance of interdisciplinary research that matured quickly as a discipline on its own. But now we are concerned not with empty spaces but the contrary, with overlapping, with territory in which two or more disciplines have something to say, and where there is apparent contradiction between their conclusions and policy recommendations.

The social usefulness of the social sciences has always revolved around their application to policy, while the physical sciences stayed with physical problems. But now policy advice is not offered by social science alone; there are strong incentives to physical science to enter that field. And so the range of disciplines converging on a single question is increased. Writings on atmospheric warming and what ought to be done about it are signed by authors from a dozen disciplines, each showing the marks of his or her own background.

We will see that in most of the natural sciences the ideal of experimentation is to keep all "irrelevant" factors the same between the experimental group and the control group, thus allowing the effect of the factor of interest to stand out unambiguously. Social scientists, on the other hand, typically want to know the effect of the factor of interest when associated changes take place as they do in the real world. "Who cares," one can imagine the economist saying, "what would happen when we run out of oil if all other prices and technologies remain unchanged? We want to know what will happen if we run out of oil and the changes associated with this exhaustion of oil take place—including the rise in the price of alternative

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As an example, for good or ill, the scientist speaking as environmentalist often speaks less dispassionately than the economist who often sees himself as applying the tools of his trade to, from his point of view, yet another economic problem.

Individuals in an organization like our own have to hold to the highest standards of both commitment and truth—honoring it where we see it and pursuing it where we can. In so doing, we have to attempt the difficult task of preventing our commitment from shading the truth and our truths from shading our commitment.

As our organization moves into issues of global security over and beyond those of nuclear security and war and peace, this article can remind us of certain desirable rules of interaction.

Scientists reaching across disciplinary lines have to be more respectful, patient and tolerant of each other than is often the case. In the trans-science issues of sustainable development, those who say of two combatants: "They can't both be right" may, in fact, be wrong. The different disciplines have much to teach the other. And their perspectives may be justified even when their facts are inaccurate or their analyses imperfectly developed.

Policy pronouncements, based on disciplinary analyses, have to be examined very carefully for hidden assumptions and agendas. The "science" may be the easiest part of many questions. What the science implies for policy can be much harder. Methods have to be developed for grilling the individual scientists (as in FAS's "Scientists' Hearings") to make sure the assumptions of the scientists are congruent with the assumptions of the policy-maker.

And the answer to disciplinary differences may be to bring in more disciplines. In particular, to bring responsive and relevant policy out of disparate views of such contending disciplines as ecology and economics, we are going to need help from philosophy and ethics, and from sociology and anthropology and all the rest. ■

Anfinsen Dies

Christian B. Anfinsen, Nobel Prize winning biochemist and a sponsor and two-time Vice Chairman of FAS, died recently at the age of 79.

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fuels and new discoveries taking place under the impulsion of such price changes." This difference, which goes back to the earliest and most basic training of the two groups of scholars, is one only of the elements that underlie the difference in their conclusions.

Points of Conflict and The Harm Done

The dominant view of biology on questions like the extinction of species is that we are on a track that can deprive mankind of its physical base, of its very life support system, while economists write that in the worst case we risk a deduction of one or two percentage points of annual growth. Biology disregards substitution, while economics emphasizes it and its ability to make up for loss of a raw material or a species of plant or animal. Due to blind spots within their respective disciplines, that lead them to public announcements of conflicting policy recommendations, scientists in effect ask the public and administrators to resolve a question that is too difficult for themselves.

The administrator has his own way of resolving such a matter. If he 'just knows' that our environment is in danger he will seek advice from Paul Ehrlich or Herman Daly or Edward Wilson or Peter Raven or any one of a hundred lesser figures whose thinking is similar to his own. If he 'just knows' that the best course is to get on with development, and after we become rich will be time enough to look into the environment, he will consult Gale Johnson or T.N. Srinivasan or Julian Simon.

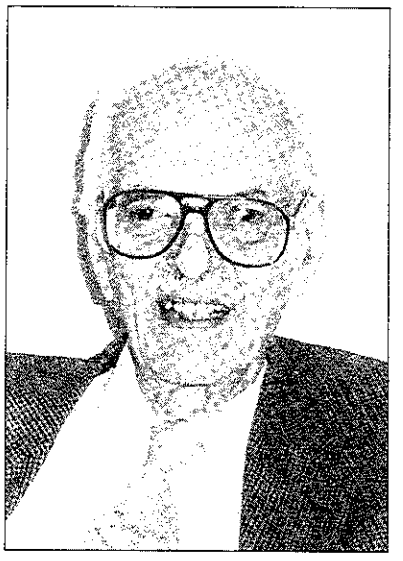
Thus, either way the administrator gets the answer he seeks. That makes nonsense of the entire policy consultation process, and throws doubt on the scientific enterprise as well.

Equally nonconstructive, a case comes up in a US court and the defendant, needing to prove that the release of toxic material has done no harm, finds a friendly economist to back that claim. But if the defendant has a scientist, so has the plaintiff, and a quite different version of the matter is enunciated from the same witness stand by the ecologist. The American judicial system seems to provide an especially strong incentive to this less than constructive use of science. Whether the judge decides for the one or the other, or pronounces a compromise, there is one sure loser, and that is science.

Public respect mattered less in the days when science was carried out by gentlemen (rarely by ladies) at their own expense, or by the scientists whom they patronized. As that source of funding has diminished in comparison with public funding, the public standing of science becomes very important indeed. Public interference with science as a condition of funding is hardly welcomed, yet today scientists have to take consolation from the fact that it is their accelerating success in discovery that has brought public funds and hence public scrutiny into their previously private world.

Causes of The Conflicts

We will see that in some common instances the source of the contradiction is simple and remediable. This is in cases where the disciplines answer different questions that look alike and the contradiction can be removed by a simple



Nathan Keyfitz

restatement of their assertions. Economists who use the Gross Domestic Product (GDP) as a measure of welfare arouse the ire of sociologists and environmentalists; all can accept that the GDP is an accurate and extremely valuable measure of the magnitude of the *commercial* economy.

In other instances the difference goes deeper, and only by each getting to know the other's discipline in some depth will the source of contradiction be found. That is not easy. Even if there were no defensiveness on either side, for mature scholars who have attained distinction in one discipline to start out as novices in another is hard and unpleasant work and likely to bring little reward within their own professional community. Yet aside from resolving the dispute such study can serve a purpose within one's own discipline in helping to define the domain of its correct application. And unless more of it is done we will see continued unnecessary disputes among scientists and further decline in the influence of science on policy.

Any science that builds heavily on theory is bound to include assumptions. Nothing can be done in economics, as nothing can be done in physics, without some assumptions. Yet care needs to be exercised in the handling of these. Donald Saari gives some examples, pointing out the very basic way in which choices among three items differ from choices among two.

Suppose three commodities, A, B, and C, of which A has a plurality of first choice votes, B comes second, C third. In the usual demand scheme, as in voting, second and third choices are disregarded, so A wins. But second and third choices could be such as to make it obvious that A is not really the preferred candidate.

It was Kenneth Arrow who first showed the impossibility of simultaneously meeting the several reasonable conditions for fair multiple choice. Demand curves based on first choices only, as in economics, would be greatly altered (and unfortunately also greatly complicated) by adding dimensions of

choice beyond the first. Similarly, Ricardo's proof of comparative advantage applies to two parties, not to three or more, says too little about internal distributional effects, and assumes no capital movement that would restructure the two economies; he was aware of these essential conditions of his theorem, but they are rarely referred to in political debate by proponents of free trade.

I proceed to six examples of the varied subject matters of the oppositions that are our concern, every one a report of disputes that I have myself observed. If my reporting is successful it will give some sense of why scientists are not only uncomprehending but sometimes angry and frustrated by other scientists.

Six Apparent Mutual Contradictions

• 1. **Mortality and Population Increase** Infant mortality would seem from one perspective to reduce the number of children who grow to maturity, and hence to hold down the increase of the population of a poor country. That is what Garret Hardin (1992), a *biologist*, believes, and it leads to the policy conclusion that well-intentioned help to the Third World to reduce infant mortality is likely only to lead to more adults who will die of hunger.

But, say *demographers* almost unanimously, that is only true when the infant deaths are considered in isolation. If the fall in mortality is part of a development process that includes education, especially the education of women, as well as rising incomes, then births are observed to be fewer, and the fall in infant mortality does not raise the rate of natural increase but the contrary. In no country that I can think of does one find low infant mortality along with a high rate of natural increase.

In industrial countries, where birth control is nearly universal and childbearing is already far below natural fertility, different relations can apply. If, for example, couples have a target number of children in mind and they replace infant deaths to attain the target of living children, then reducing infant mortality is of course a good in itself, but it makes little difference to the rate at which population increases.

Close study is needed to reveal the different questions that the disciplines ask. Overly enthusiastic practitioners of disciplines are often culpable when they do not make clear the restricted scope of the questions they ask and hence of the answers they give. What look superficially like the same questions are different enough in different disciplines that they can have quite opposite answers, both based on relatively clear-cut evidence.

Rose Frisch is the physiologist asking, "If nothing else changes, will better nutrition produce more children?" and is able to show that it will with some solid data, thoroughly controlled for "extraneous" variables. Frank Notestein on the other hand was the demographer asking, "If nutrition improves, along with the spread of education and the freeing of women, will more children be born?" and the answer to this formulation is "No, there will be fewer children, certainly over a long period of time." His theory of the demographic transition, (Notestein, 1945) and that of Kingsley Davis (also, 1945) present solid empirical evidence for the demographic view, this time based on historical data with "extraneous" variables varying.

We emphasize that physiologists who study the matter do so by means of controlled experiments, with great effort made to hold associated elements constant. In fact if there is one feature common to experimental techniques in all of science it is ingenious ways of avoiding the entry of any variables into an experiment other than the ones specifically under study. If physiologists are interested in the effect of nutrition when everything else is constant, while demographers are interested in what happens in a world in which everything varies together, then the problems they are dealing with are beyond bridging with any amount of goodwill; they have to be recognized as simply different.

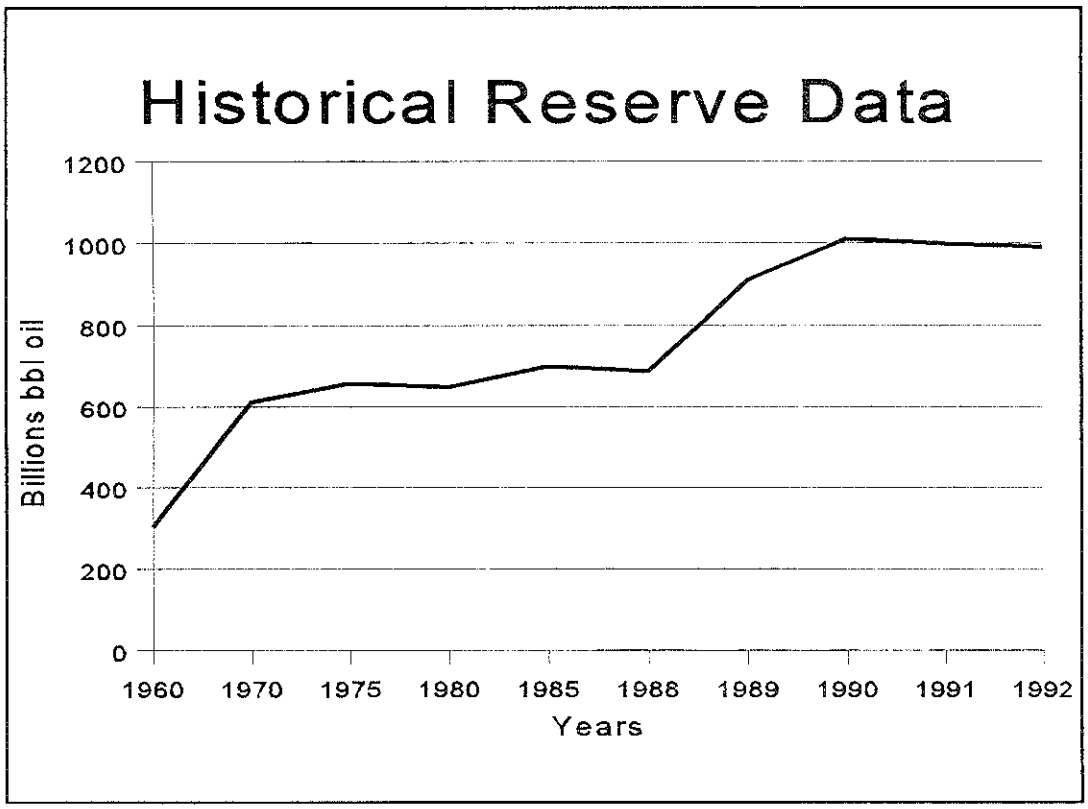
• 2. **Exhaustion of Energy Resources** For an *oil engineer* there is only so much oil in the ground, and though we do not know whether it is much or little, whatever we draw out and use reduces the amount, and so brings closer the day when we will be short of energy.

But that overlooks the possibility of substitution, says the *economist;* no sudden exhaustion of underground sources is possible, but only a gradual increase in the cost of extraction; we will have plenty of warning as the end of the supply comes into sight—the price will rise, there will be a premium on seeking new sources of energy. Over the long period of higher and higher priced oil (a period that has not yet begun) substitution of other sources of energy will surely take place. That is why no real energy crisis is ever likely, say those who follow this line of analysis.

• 3. **Efficient Lighting** When we use a new design of light bulb that saves two-thirds of the thermally-generated energy required for lighting a room, the engineer will be satisfied that only one-third as much electricity is drawn and that only one-third as much carbon dioxide is produced, and the householder is pleased with having saved two-thirds of the lighting expense.

But the *social scientist*, Sture Öberg in this case, asks a further question: what will the householder do with the money saved? Suppose that it is added to a bank account that is later spent on a heavier car, or spent more immediately on a pleasure trip by plane, or used to run an air conditioner at a colder temperature. The net energy saving due to the better light bulb could be small, though probably above zero. Zero is an unlikely extreme, but before we can assert even this we have to be told the energy cost of the householder's marginal expenditure. And this is something that depends on the person's culture. A choice of what to spend money on can at one time and place run to heavy cars and long-distance travel, at another time and place to computer games, amateur gardening or, best of all for saving energy, meditation.

The advantage of the engineer's answer is that it is independent of culture; it is clear cut conceptually, measurable, and straightforward. And it is what the householder needs in deciding with which bulb to equip his premises. Its disadvantage is that it is incomplete. If the state is considering subsidizing a light bulb factory that will produce the more efficient bulb, it is the social scientist's estimate that is needed for the decision if overall energy saving is the objective.



New exploration technologies have steadily increased the total proved worldwide oil reserves.

One can understand why such a statement seems less than constructive to the engineer. It clouds the issue. If the social scientist could only offer an equally precise and measurable alternative statement the engineer would be prepared to take it seriously, but the trouble is that the social science answer depends on variables that will only be known after the fact. Pending that ex post facto knowledge the answer can only be made determinate by guesses on the future, in this case on the future taste for travel and other energy-expensive activities, that are notoriously inaccurate.

• 4. **Pregnancy Termination** How many births does a miscarriage prevent? Obviously "One", answers the *physiologist* or the attending *physician*. Not so obvious, says the *demographer*. Only if subsequent childbearing is exactly the same as though that miscarriage had been a live birth, is "One" the answer. But this sequence is improbable; couples are likely to have their next birth sooner after a miscarriage. If the woman is fertile and proceeds immediately to another conception the loss of births can be far less than one. One can imagine a long series of miscarriages, far too numerous for every one of them to have been a birth.

One way to think about the matter is in terms of the "availability" of the woman for conception. With a birth she is unavailable for the nine months of pregnancy, plus some time for postpartum infertility, plus some time in which it is the custom to avoid pregnancy, in all something between one and two years. With a miscarriage the unavailable or infertile time is much less, say on the average something like six months. If a birth 'costs' 18 months of her time, and a miscarriage only 6 months, then as a first approximation one can say that a miscarriage prevents one-third of a birth.

But the same thing can be said here as in the other cases: who knows how long the woman will wait to have another try after a birth and a miscarriage respectively? Of one thing we can be sure: they are not likely to be the same. Like the engineer's answer in the light bulb case, the physiologist's answer is simple, precise and narrow; social science takes account of more conditions, and that makes it less precise.

• 5. **Tax Revenues** A new expenditure tax is proposed; the purely technical *accountant* or *tax expert* will often calculate the resulting treasury receipts from the previous pattern of expenditure. That is simple and in its frame can be claimed to be 'exact'. *Economists* on the other hand insist that people alter their expenditures in a direction that lightens the impact of a tax; that is why, they say, tax collections resulting from a change in legislation turn out to be less than promised by the specialized expert. Economists apply appropriate theory rather than the multiplication table. But again they have to depend on something close to guesswork for the human variables.

• 6. **National Income** The Gross Domestic Product is often used, not only by journalists, but even by *some economists*, as the best comprehensive measure of well-being to be had, so *sociologists* as well as the public are puzzled when the GDP is increasing rapidly, and at the same time crime, drugs, the number of homeless, noxious city air, traffic jams, divorce, one-person and one-parent households, are also rising. How can well-being be on the rise when the conditions usually thought to conduce to happiness are deteriorating?

Harvard economist Amartya Sen (this year's President of the American Economic Association) shows the rather low correlation of the nations' GDP per capita with their infant mortality, life expectancy at birth, hunger and famine, literacy, and other unquestioned indicators of well-being or misery. Among other conclusions she made in 1993 is that "mortality data provides a gauge of economic deprivation that goes well beyond the conventional focus on income and financial means," which I interpret as meaning that if we care about welfare and deprivation there are better indicators of them than GDP.

These examples all have one feature in common: each is answered by a specialist who considers only the particular circumstances in isolation from other concomitant changes; a social scientist considers the question in context. Only very slightly different is the national income, not an independent discipline in having academic departments devoted to it, but similar in having practitioners whose careers are involved with it, and outsiders who do not share its perspective.

Other Instances

The above six examples come from experiences in which I have actually been present at meetings where disputes occurred. I see accounts of other "mutual contradictions" of which I have made no direct observations.

For instance, *population geneticists* and *population ecologists* approach evolutionary problems from different perspectives. The geneticist regards gene frequencies as the common denominator of evolutionary events, whereas the ecologist is more interested in organisms, their numbers and life history attributes. For the geneticists the quip is "The purpose of the chicken is to allow one egg to produce another egg," while for the ecologist the chicken, that exists between the production of eggs, counts for its effects as an organism.

Julian Simon, Economist

Undoubtedly the increasing specialization in the world of science gives rise not only to the cases I know about but to many other conflicting pairs of disciplines that I am not in a position even to list.

Assumptions: A Cause of Apparent Contradiction

The contradictory answers given to particular questions are frequently due to the different assumptions in which the work is framed. The assumptions of interest for our purpose are always stylized, always contain an element of convention. The question to be asked about them is never whether they are true, but only whether their departure from reality matters for the purpose in hand. The conflicts discussed in this paper arise because an assumption that is sufficiently true in the context of one discipline is sufficiently far from the assumptions made by another discipline as to be grossly in error from its viewpoint. I stress the intermediate truth status of the assumptions on which theories are based: while they are never exactly 'true', those used in respectable disciplines are never clearly 'wrong'; they always depart from reality, and the issue is always whether the departure from reality is 'serious'. To define these terms precisely would take us too far afield.

What is relevant for the oppositions listed above is the amount of patient study required to find out just what the assumptions are. If the disciplines are guilty of anything it is their failure to reveal their assumptions in a form that will be easy for outsiders, in particular administrators who use their work, to understand. They put their conclusions in large letters and bold face; the assumptions are mentioned, but in fine print. We expect higher standards of truth in labelling from scientists. This is never a matter of ignorance on the part of the discipline in question, but only that in public communication its practitioners forget what their own literature tells them.

Impatient readers are in collusion with this down-playing of assumptions; they want things simple. A Senator has told us that he does not want to hear 'On the one hand ... and on the other hand ...' He wants one-handed consultants. But the science that can answer every question with yes or no does not exist. By taking the questions broadly and extracting from the scientific witness a clear-cut answer, the questioner rides over the differences between the disciplines. What is the effect of energy use? No one can answer that as it stands, except by asking "Effect when, and on what?" Economics tells the effect of energy use in the short run, and not its effect on everything but only on productive commercial activities in free markets. Biology tells the effect, also not on everything, but on living systems, and over a much longer period of time. Efficiency is the goal of economics while survival is what counts in biology, and these very different aims underlie this as well as many other matters with which the respective disciplines deal.

Efficiency and Sustainability

Efficiency and survival of species are both perfectly legitimate ways of regarding the world fishery, where short-run efficiency can be consistent with the long-run extinction of commercial species. Once we realize what economic efficiency means, as well as the biological circumstances that lead to extinction, efficiency and extinction can coexist in theory as they do in reality. The way most economic calculations are done, they concern what mathematicians call a "local maximum", while biologists think not in local but in global terms—the ultimate extinction or continuance of the fishery is what interests them, the condition not tomorrow but a decade or a century from now.

Lake Erie's commercial fishery may have reached a local peak of efficiency just before the system switched to a new configuration—one in which valuable fish were replaced by eel-like creatures, lampreys, of no commercial value. There is nothing technically wrong with a local maximum, but it should be recognized as such.

Unspoken Differences vs Contradictions

As the time reference was different for two disciplines considering the fishery, it accounts for other interdisciplinary differences. The physiologist has in mind an immediate result, say within a year or two; the demographer is thinking in terms of decades. When the undernourished woman is well fed for even a season her monthly cycles are likely to return and she could have a child that otherwise could not be conceived.

On the other hand—the population better nourished, its women coming to be liberated and given access to education—is a social process that takes time. It would be foolish to expect that the negative impact on fertility could show even its first beginnings in less than 10 to 20 years, while the positive effect can show in one or two years. Anatole Romaniuk shows the rise for Zaire, and for the James Bay Indians. Demographers and economists see these as short-run effects, valid with the immediate effects of nutrition, and to be countered as the usual accompaniments of better nutrition take hold.

Do these cases, which apparently yield genuine empirical data, reveal a contradiction? Not at all. What they reveal is that within the two disciplines there are understandings of the scope of results—in this case the time scales—that professionals have so thoroughly in mind that it would be dreary to state them when communicating with others in their discipline.

Innumerable examples can be offered of conditions that are kept in mind without any need for repetition. Every economist knows that competitors can exist in stable equilibrium only on condition that there are diminishing returns to scale. If a larger firm has lower costs then this slight advantage over its competitors gives it a further advantage, and so it continues to increase in size. Only one equilibrium is possible—a single monopoly firm that has undersold all its rivals and driven them out of the market. Though every economist is aware of this requirement for stability, it needs repetition for disciplinary "foreigners".

Among the various interdisciplinary conflicts, one has been particularly conspicuous in public debate—the disagreement between mainstream economics and biology on the urgency of population control. Here it is not a matter of just one unstated assumption that divides the two; there are many, and even the set presented below is far from complete.

Biology and Economics

One could quote endlessly to demonstrate the sharp difference between biology and economics on a subject of intense public concern: population growth. For instance David E. Bell, a respected economist and foundation executive, once Director of the US Bureau of the Budget, says:

"In the 1950s and 1960s ... there was much concern in the United States that world population growth would outrun the world's resources, leading to widespread famine, social disruption, and conflict ... Cutting the rate of population growth was seen by many as an urgent necessity to prevent worldwide disaster ... In retrospect, these fears were greatly exaggerated. In fact, the record of the past three decades has been remarkably good."

World Population and US Policy, 1986

And as for the future,

"There are no natural limits to the ability of the planet to support a great many more than 5 billion people."

The London Economist, June 13, 1987

On the other side is the joint statement of the US National Academy of Sciences and the venerable and equally distinguished Royal Society of London, that between them include a high proportion of the world's most creative scientists. According to its preamble:

"If current predictions of population growth prove accurate and patterns of human activity on the planet remain unchanged, science and technology may not be able to prevent either irreversible degradation of the environment or continued poverty for much of the world."

Population Growth, Resource Consumption and a Sustainable World, 1992

Paul Ehrlich, Biologist

Recently, I have attempted to examine the questions of population, development and envi-ronment the hard way: by attempting to take account of the knowledge acquired by both biology and economics.

There is a sense of contingency on the part of biologists, who think of the dinosaurs who lived on the earth 100 million years against a mere one or two millions for humans. Economics sees straight-line progress, sometimes faster and sometimes slower, but always in the same direction. For economists growth is now the normal condition; for biologists it is an aberration—an admirable one up to a point—of the last century or two. Biology sees mankind arriving where it now is by adapting to the natural world, as against, on the part of economists, the intervention of consciousness, and the view that mankind is creative and not merely adaptive.

Briefly, my examination resulted in the following eight axes, which may constitute a beginning point for further study:

- 1. Economics deals with growth, steady progress as against biological contingency. Evolutionary history has been by no means smooth. From its study of this history biology is better prepared than most other disciplines to consider catastrophes resulting from human action.
- 2. Scholars like the material they study and seek the well-being of their subjects. Ecologists are accused of liking species, while economists like growth and consumption. Are more consumer goods preferable to the sparing of trees? Here reason fails and we fall into the quicksand of values.
- 3. Economics sees indefinite market-driven substitutability as a result of scientific discovery; natural scientists whose discoveries make possible the substitutions are skeptical. Should natural scientists have more confidence in their own abilities, or should economists have less?
- 4. Economics makes people the exclusive object of terrestrial action; biology takes them as one species among many in a web of life. Can one species detach itself from the totality of life on the planet, and act entirely on its own initiative, as

the book of *Genesis* authorizes man to do?

- 5. Economic action is on a time scale of years or decades, far short of the millennia and eons of biology's evolutionary time. For the very short run population and economic growth make no difference to the environment.
- 6. Economics cares little about scale, but is concerned with proportions and their allocation, biology with absolute size in relation to the biosphere. The point is made by Herman Daly; Allen Kelley answers that data to incorporate scale are lacking. So far we have no way of measuring the overall capacity of the biosphere.
- 7. Economics deals with a truncated part of the commodity cycle, the relatively short period when the goods are on the market, while ecology aims at the whole cycle. If goods disappeared into thin air at the moment of sale the planet could stand far more of them.
- 8. Both disciplines are empirical, but use different kinds of data, with which neither is wholly satisfied. No one is sure just what data will decide the population question to the satisfaction of both sides.

Population Pressure: Some Generalizations

Population pressure has positive as well as negative features, and it takes different cultural contexts to reveal these. The enormous variation among cultures makes generalization difficult. Thus examples can be offered of conditions in which population pressure resulted not only in specialization, as Adam Smith (1776), Durkheim (1893) and many since have said it would, but also in a drastic change of institutions towards a regime of private property, where before property had been held in common.

In other instances, the culture is such that increased population accentuates the preexisting sense of community, and common property comes to be more strongly established rather than less.

The case I know best is East Java, where according to tradition the land is to be redivided in each generation, with families receiving an area proportional to the number of persons to be supported, including children. The incentive effect on childbearing needs no elucidation, and the result is what Clifford Geertz has called "shared poverty." The tradition is no longer observed, but there are enough other elements of community mutual help to justify Geertz's expression.

Ethics as Fall-back

Gale Johnson and Paul Ehrlich, Herman Daly and Julian Simon, all draw very different conclusions from their scientific knowledge on the advantages and disadvantages of population growth, but all end up at the same place—make contraceptives freely available whatever the cost. Couples have an absolute right to determine the number of their children. Some say that it is important to ensure that right for reasons within their discipline, others that it is less important, but still should be done for moral reasons that go beyond any discipline.

Thus, revisionist economics shows that the economic gain in controlling population is small, and in some instances could even be negative, and then ends by saying that control ought nonetheless to be encouraged on ethical grounds. But the economist's specialized expertise does not include ethics. In other places economics teaches that such personal opinions are valueless for social science, and insists again and again that the discipline is value-free. That economics has been able to stay with this value-free self-restraint is one of the features that has made it stand so high as a scientific discipline, that entitles it to be called "queen of the social sciences."

Why, then, does revisionist economics not stay within traditional boundaries, and end by saying that because of the benefits of the division of labor and similar propositions larger populations have clear advantages and should be encouraged? As I read the purely economic sections of the Report of the National Research Council (1986) mentioned earlier, the arguments for increased population would seem to outweigh the arguments against it. In what other field does economics back off from its own conclusions on ethical grounds?

Does this example uncover a key to the unification of the sciences? The present paper has repeatedly complained of the opposing conclusions of the several disciplines, and the weakening of their influence that results. Can they be brought together by universal agreement on such propositions as "the strongest case for spreading knowledge of contraception is the right of parents to determine the number of their children"? Or is it just an accident applicable to this case only that an indisputable moral principle has a unifying effect that overrides interdisciplinary differences?

Exaggerating A Discipline's Scope Can Damage It

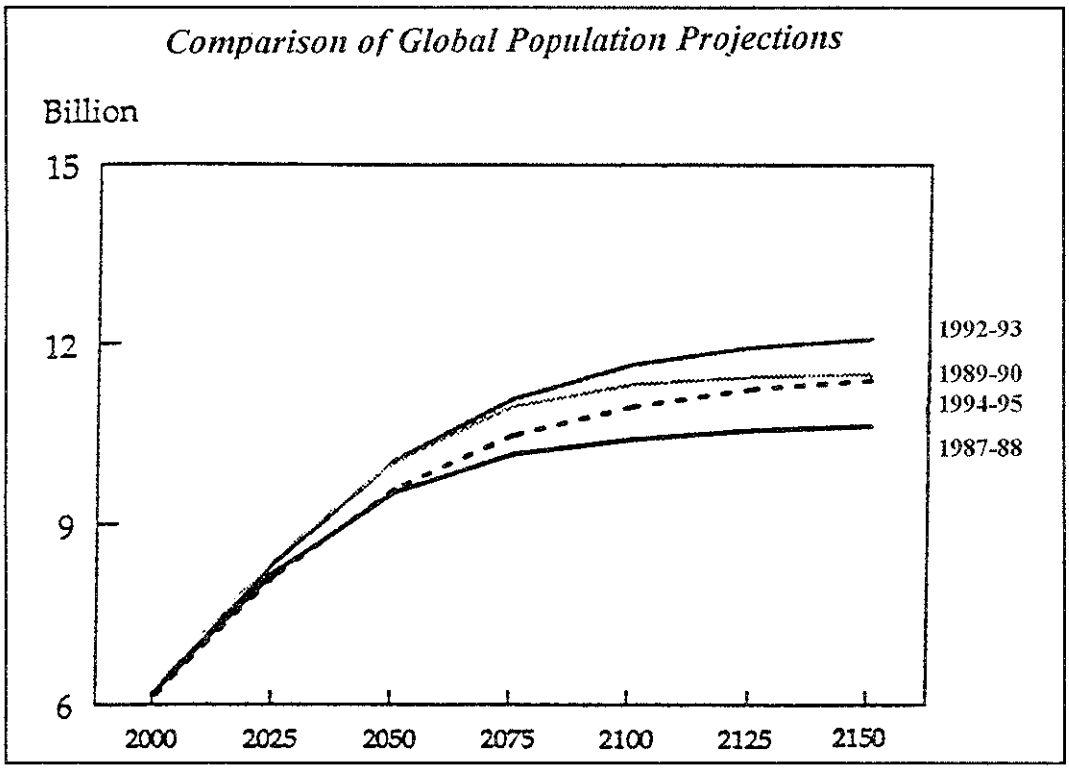
If their customary discourse sounds as though the disciplines are contradicting one another, it is because the listener has not heard the qualifications on the results attained by each. Perhaps the qualifications have not been stated loudly enough, perhaps some not stated at all outside of narrow professional circles. More emphasis is needed on these qualifications than the respective disciplines are inclined to provide. Practitioners like to think of their results as having the widest possible scope, and with this wide scope the disciplines seem to overlap, to be answering the same question.

That can be self-destructive: in the natural wish to extend to the maximum the scope of its science, its field of application and its importance, a discipline makes light of some of the restrictions on its findings, and so does another discipline; making each more general than its data permit causes the two to sound as though they are answering the same question; their different answers contradict one another; the public loses confidence in both and both suffer in prestige and in public support.

To summarize all this in one sentence: mature empirical disciplines, using data drawn from what common sense sees as the same reality, do not in general contradict one another, but only seem to do so because they are really answering different questions that may have been carelessly expressed in the same words. The first step in interdisciplinary work is specification

of the assumptions in the two disciplines, finding out what really are the questions that they respectively are answering. This is not new research—internal criticism within disciplines ensures that each is thoroughly familiar with the assumptions on which its conclusions depend. The only change required is greater frankness with outsiders.

In other prior papers on these issues, I have quoted actual words of proponents of the contrary views, and need not repeat these. What needs emphasis here is that these contrary views are not those of individuals, but are on the whole associated with disciplines. But since they often come to the public without disciplinary labels, they sound like the utterances of so many individuals, and give an impression of disorder in the house of science that is far from what the participants want. In that condition of apparent disorder lay people believe they have every right to express opinions without any need to consider what science knows about the subject.



This graph compares four projections of median population for the first half of the next century. Made by the World Bank between 1987 and 1995, they forecast almost identical increases in the first 25 years. But by 2050 the projections vary by over 1 billion. These median projections are further bounded by high and low variants which in the most recent edition of the World Bank Report were 7.9 billion and 11.9 billion in 2050.

Public Support and Consequential Expectations

When two disciplines come to very different, even opposing, views on a matter of practical consequence then they cancel one another out, so that neither has much influence on policy. Neither legislators nor administrators have to pay attention, so science is disregarded in the formation of policy. Such disregard of science suited earlier centuries, when research was carried out mostly as a hobby of the rich, or was supported by wealthy benefactors with little expectation that its results would be useful. Scientists, like the scholastics of the middle ages, could argue as they wished, and no harm would be done because no one expected any outcome of practical value.

Today is different; support from the public purse is substantial, and so are public expectations of the return. In return for the support it provides, the public has a right to know the scientific facts on population, the economy, and the environment. Hearing multiple conflicting answers is the equivalent of no information at all.

Methods of Conflict Resolution

I ask readers to put themselves in the place of an administrator trying to make a decision. The administrator hears from such distinguished scholars as D. Gale Johnson, or T.N. Srinivasan, or Samuel Preston, that the environmental crisis is exaggerated, that problems today are not very different from those of the past. He also hears the equally distinguished E.O. Wilson, Peter Raven, Paul Ehrlich and Stephen Gould say that assaults on the environment are bad and getting worse, that irreversible damage is being done. How are outsiders to decide, given that we do not have the competence to make an independent judgment? Do we count names of members of the NAS on the two sides, perhaps weighting Nobel laureates as worth five ordinary members?

To fall back on such statistical counts to decide a point of science is absurd, and sophisticated people in fact proceed differently. The members of the Committee that wrote the 1986 report of the National Research Council were mostly economists, while those who wrote the 1992 joint Statement of the Royal Society of London and the NAS (*Population Growth, Resource Consumption and a Sustainable World*) were the officers of the Academy, who responded to the majority of members, among whom biologists are numerous. The statement was not put to a vote of the membership, but it was approved by the Council, that represents the membership in the same sense that Parliament represents the voting population.

The 1986 report is still being quoted as representing the Academy. We scholars may not decide such matters by vote, but we are evidently democratic enough that each group gets its turn to represent the Academy. We ought to be able to do better than that, for like voting to decide substantive questions

Herman Daly, Economist

what now goes on is equivalent to an abdication. By not agreeing among ourselves we put the decision on the facts into the hands of administrators who consult us, surely less competent on the matters in question than ourselves, or of the public, who in turn reflect the opinions they find in the media. That route of decision making on what should be done can hardly incorporate the best thinking of science.

Many efforts have been made to obtain consistent answers on this and other divergences between disciplines that would make use of what is known. I have been at more than one meeting specifically intended to bring disciplines together. They were announced as debates, and were festive occasions with plenty of amiable goodwill, but no real debate took place. Each side simply expounded elementary economics, or elementary evolutionary theory, or elementary physiology, and at no point closing in on the arguments of the opposition.

The quickness of scholars to confront issues within their own discipline, to enter into the thinking of co-disciplinarians who criticize them, is not matched by attention to arguments that come from outside the discipline. A debate requires listening to the other side, and dealing with the points it raises; it is the listening that is the hardest part.

Criticism that comes from within the discipline cannot be disregarded with impunity; one is compelled by powerful sanctions to listen to internal critics. Elaborate machinery for review and publication filters the conclusions of any recognized discipline. What has given science its power is as much as anything the highly developed institutions for detection of fallacious argument or unsuitable data. It is not necessary here to review the ways in which disciplines resolve internal differences; such resolution is a main purpose of their institutions.

Clear-cut Engineering? Uncertain social science?

In examples of interdisciplinary disagreement such as those above we often find that one discipline defines the problem narrowly, and rather easily reaches a sharp conclusion. The physician contemplating a miscarriage, the biologist discussing infant mortality, the engineer on the energy-saving light bulb, each can provide determinate and precise answers to the simple questions that these ask. For the professional tasks that they have been trained to handle effectively these are the whole answer: the engineer is not typically called on to think of the effect on society's energy supplies but only to provide maximum savings of energy in particular applications.

Such practical people are understandably irritated by the student in another discipline who takes a wider view, and tells them that their exact answer is not applicable to the broader and socially more important question. The social scientist sets the physical facts inside a framework of human behavior, which, he would insist, is where they are really located. That naturally enough annoys the engineer who finds his clear-cut answer muddied by considerations that are not readily quantifiable.

A Method for Interdisciplinary Study

Exhortations to interdisciplinary study have gone on through most of this century, and yet much too little such study goes on. It takes more than generalized good will to cause scholars to modify their habits of thought; we are all prisoners of the culture in which we have lived from our earliest contact with scholarship. Underlying the debates on facts and hypotheses are different perspectives on the world. Not only learning the facts of the opposing discipline is required, but entering into its ways of thinking.

That that is essential for the advance of science as a whole does not make it easy for mature individuals to achieve. Perhaps it may even be said that the more distinguished they are in their own disciplines the harder they find it to concentrate on the culture of another discipline; the consequence of that is that much of what passes for interdisciplinary study is less than first-rate.

Disputes between disciplines have a potentially constructive outcome for the disciplines themselves. That is to make clearer to each what are the assumptions contained in its own work and thinking, and their importance for its policy conclusions. The assumptions are usually well known to practitioners, but they are not emphasized because they are not considered to affect the results. The approach by an alien discipline with a wholly different set of concepts and working hypotheses reveals points where the assumptions are in fact decisive.

But another element enters that frustrates any facile proposal for reconciliation. Differences between groups of scholars, like those between nations, can be based on deeply held cultural divergences, and very different sets of values. There is indeed good reason for scholars to try to remove the acrimony on environmental and other matters, for while it continues it weakens the support for all science. If this article contributes to understanding of why the differences arise it could in at least a small degree advance the cause of reconciliation.

—Nathan Keyfitz

Editor's Note: This article will soon be published in its unabridged form, complete with references, by Kluwer Academic Publishers in *Policy Sciences*. It is printed here by the permission of the publisher.

FAS Site on World Wide Web

The Federation has established itself on the Internet. To reach the FAS Homepage, address:

http://www.fas.org/pub/gen/fas

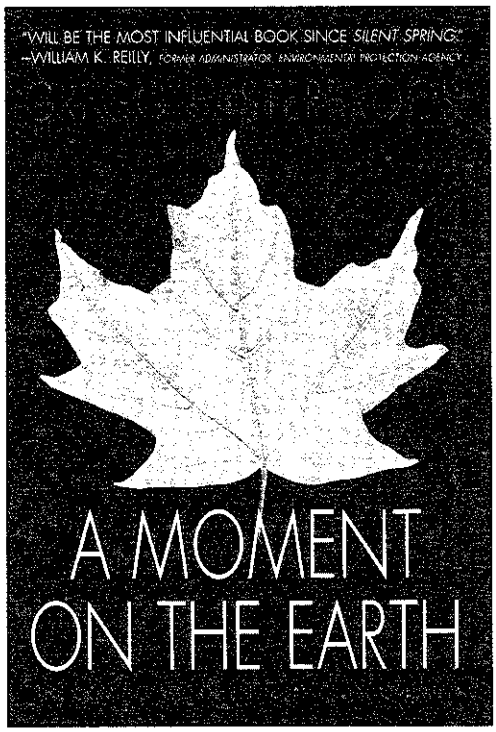
Although the site is still "under construction," basic information about all FAS policy projects is in place and a number of recent publications can be accessed.

Daring Assessment of "A Moment on the Earth"

A *Newsweek* science reporter, Gregg Easterbrook, has provided, in a 700-page book, a broad-ranging review of two dozen fronts in the war to protect the environment, from acid rain to water and points in between—land, farms, global warming, toxic wastes, and population.

Unlike almost everyone else, this science writer has kept track of who said what and who hit whom in each of these disputational arenas for the last few decades. Accordingly—while it is obvious that all readers will disagree with his conclusions in one or more areas—his comprehensive book is a welcome opportunity to take stock of where the movement is.

Easterbrook urges "logic, not sentiment" and accuracy rather than "expressions of panic". And since he is a self-characterized liberal and environmentalist, it is difficult for opponents to dismiss him as an anti-environmentalist. Indeed, he thinks that environmentalism will bind nations together and is "the best thing that's ever happened to international relations". He advances a philosophy of "ecorealism" rather than "ecopessimism" and weighs in on the optimistic side.



In his view the war is going well in the First World where environmental problems are, generally, peaking. And until this progress is recognized, he believes, the environmentalists will not be motivated to attack the real environmental problem of the developing world where a few billion people live in real poverty amidst real environmental degradation.

Some in the environmental movement may see this book as a threat to the maintenance of the army of environmentalists created since 1970. The movement is used to books consciously designed to sound a trumpet call. These bibles of the movement may give scant attention to any favorable trends, or proclaim that the future of "the Planet" will be decided in the next decade or two.

Daring or Safe To Be an Environmentalists

Easterbrook says it was once the "daring position" to be an environmentalist, but that it is now the "safe position'' since people get upset when you say that things "may turn out fine". There is much truth to this although Vice President Gore, criticized in the book for excessive "doom-saying," recently proclaimed a certain amount of victory in a recent *New York Times* op-ed. And our own Denis Hayes, national coordinator of the first Earth Day, recently wrote that "the environmental movement may well be the most successful social movement in American history".

A favorable review in the *Boston Globe* called Easterbrook's book "long overdue, challenging fundamental assumptions about our role in the Earth's future". *The New York Times* said the book "deserves to be read, investigated, argued about and honored".

How many of his conclusions will be borne out is, inevitably, uncertain. The point is not, really, whether he is "always right" since, on this scale of subject, no one could possibly claim to be assessed to be so. But this is a well-written, thoughtful, balanced, stimulating, and undoubtedly courageous, book. It is more than a collection of opinions. No one can fail to learn a great deal from it because it contains facts and quotations from experts in the tradition of good science writing.

Scientists Respond to Different Drummers

As the Keyfitz article in this issue of the *Public Interest Report* points out, scientists in a particular discipline may be responsive only to criticisms from colleagues from that discipline. Or if they are leaders of the environmental movement, may take seriously only the criticisms that arise from that movement. But a science writer is judged by a wider and more dispassionate audience. *His* colleagues (other science writers) and *his* audience (the reading public) are less forgiving of exaggeration and inaccuracy. And, unlike narrow scientific papers which are not easily accessible, everyone can read the science writer. And so he must hold to certain standards. This is a most important profession.

Easterbrook sides with Bruce Ames on a number of issues involving the prevalence of natural toxins and on questioning the "linear hypothesis" in which high dose results in animals are extrapolated to lower doses in humans. He finds a number of issues important but overblown (e.g. acid rain, asbestos, PCBs). On questions of oil and non-renewable resources, he takes the side of economists who believe that such resources rarely if ever "run out" but are subject to substitution once they begin to be exhausted. He thinks oil prices will drop as a consequence of conservation and advances in renewable energy.

With regard to actions to protect against global warming, he likes the idea of carbon taxes and "marketable trading permits" in which First World companies would invest in the reduction of greenhouse emissions in developing nations if it were cheaper to do so there than here. He thinks international aid to help the developing world prosper with fuel efficiency reforms could push carbon doubling back until the 22nd century which, he posits, means it will "never happen, because society will have kicked the fossil fuel habit by then."

—Jeremy J. Stone

□

Easterbrook Peer-Reviewed by EDF

The Environmental Defense Fund (EDF) has issued critiques of a number of chapters of the Easterbrook book.

In a press release of April 18, EDF found "significant scientific errors'' with regard to toxic substances, endangered species and global warming, among others. EDF's Executive Director Fred Krupp said Easterbrook's "misstatements about actual scientific evidence" provide a "false sense of complacency about urgent problems."

On global warming, EDF's initial press release carried two complaints: the sea level rise in this century was not a "mere inch", as Easterbrook wrote, but "four to eight inches"; and Easterbrook used Fahrenheit, rather than Celsius, when he said that the 1980s were warmer than previous decades by only a third of a degree—thus minimizing the warming by about a factor of two.

On toxic substances, EDF claims Easterbrook is wrong in saying that the "bio-accumulative effects [of DDT] are nearly gone from the U.S. biosphere." On habitat loss and species extinction, EDF alleged that Easterbrook is confused between two "entirely different species of lupine"—a native plant protected under the Endangered Species Act, and that he misstated the basis of the "owl-extinction alarm."

On May 3, Easterbrook released a response, freely agreeing that "EDF is correct" in saying that *A Moment on the Earth* contains errors. He said that, amidst roughly 26,000 sentences in the book, there are three sentences "completely wrong, and about a dozen others in which a statistic or reference is flawed." These, he said, would be corrected in the next edition.

Easterbrook remained confident that "most of the new ideas I propose will win acceptance" and hoped that people would "get on with that debate" rather than to "obsess over a few genuine but secondary errors in a very long volume." He noted that each chapter of the book had been read for accuracy by at least one environmental expert and that, in particular, one of the technical reviewers was from EDF.

Gregg Easterbrook

On May 16, EDF issued a 52-page "Part One" critique of four chapters: "Global Warmth", "Radiation", "Natural Case Study: The Spotted Owl", and "Species". It had earlier indicated that it would deal, later, with "errors or shading and emphasis that cast scientific evidence in misleading terms" whether or not there were factual errors. EDP, at press time, had not decided how many more of the 30-odd chapters it would further critique.

It seems that, if EDF continues, it will provide Easterbrook, and the community at large, with a real service. They can buy the book and also order EDF's review (phone 212-505-2100, fax 212-505-2375) or they can just wait for the next edition in which no doubt, Easterbrook will clean up every serious complaint EDF has. Since EDF is, as it noted, against any "false sense of complacency," readers can be sure that its staff and related experts have given these chapter a real working over. Whatever is left will have more than a surface plausibility. It will have been peer-reviewed!

—J.J.S

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