The Economist's Approach to Pollution and Its Control

Excess pollution arises because the waste disposal capacity of the environment is provided free of charge.

Robert M. Solow

My object is not to tell you about pollution. In the nature of the case, many of you will know much more than I do about the physical and chemical causes and the biological consequences of environmental pollution. But pollution is also an economic problem, and economists have rather special ways of thinking about it, with implications for the design of environmental policy. What I can hope to do is to put the problem of pollution into the economist's framework, to see if that way of regarding it leads to any basic principles of regulation and control.

The ancient economists used to classify productive resources as Land, Labor, and Capital. In this classification "Land" stood for all those natural resources that are given in amount and cannot be augmented by human decision. Some natural resources are exhaustible: There is just a certain amount to begin with, like iron ore or oil, and when we have used it up there will be no more. If more iron ore or oil is being formed in nature, it happens much too slowly to matter to human society. Other natural resources, like water and forests, are being renewed all the time, though of course human action can interfere with the process.

In the early stages of economic development, some natural resources were "free," in the sense that there was more than enough available to saturate the demand. This was true even of agricultural land in the early history of the United States. It is still true of air and water in many places. Even if these natural resources are appropriated and a monopoly price is charged for them, they are still "free goods" to the society as the economist looks at the matter. No possible use needs to be suppressed so that some other possible use can take place.

As economic development proceeds, many resources become scarce. This may be either because a fixed supply is exhausted or, more usually, because growing population and increasing production of commodities put more pressure on the limited supply provided by nature. The use of scarce resources has to be rationed. One possibility is that the scarce resource becomes private property and is rationed by a market procedure; another possibility is that the scarce resource becomes public property and is rationed either by a market or by some other more political process. Either system may work well, or badly, depending on circumstances.

External Effects Can Distort Resource Use

Even with such a simple resource as residential land, we often find that a system of individual ownership needs public regulation because of "external effects." One person's use of a natural resource can inflict damage on other people who have no way of securing compensation, and who may not even know that they are being damaged. We would like to insure that each resource is allocated to that use in which its net social value is highest. But if the full costs of some use of a resource do not fall upon the private owner or public decision-maker, but upon someone else, then the resource is unlikely to find its way into its socially best use. We could not allow pig farmers to bid freely for residential land, for example. (There is a symmetrical case where use of a resource confers external benefits that cannot be captured by the owner or decision-maker.)

There has been much economic analysis of these "external effects," and of possible corrective measures. But first I want to get further along in the story. Eventually, as an economy grows, even air and water become scarce. Air and water have only a limited capacity to assimilate wastes or to carry them away. Any modern industrial economy apparently generates so much waste—in the form of both matter and energy—that its disposal taxes the capacity of the atmosphere, the rivers, and eventually even the ocean. We used to think that these external or environmental effects were exceptions, but in modern industrial society they may become the rule.

In the situation we have now, the assimilative capacity of air and water has become a scarce resource, but it is provided free of charge as common property to anyone with some waste to dispose of. It is easy to see that, in these circumstances, the scarce resource will be overused. The normal system of incentives is biased. A costly (that is, scarce) resource does not carry a price to reflect its scarcity. If high-sulfur fuel is cheaper to produce than low-sulfur fuel, it will be burned and sulfur dioxide wastes will be dumped into the air. Society pays a price in terms of damage to paint, to metal surfaces, to plants, and to human health. But that cost is not normally attached to the burning of high-sulfur fuel; only a part of the full social costs become private costs and influence private decisions.

If an upstream factory deposits organic waste in a river—or merely raises its temperature by using the water for cooling purposes—the costs of water purification may rise for a downstream city that wants to use the water for drinking or recreation. But these costs do not fall on the party whose decision generated them, so he has no reason to take them into account. (By the way, comparative cost analysis will often show that it is cheaper to purify the industrial waste at the source. But the choice of a method of treatment is separable from the allocation of costs. Even if it is cheaper for the downstream city to treat its water, the allocation of resources will be distorted

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unless the extra costs of downstream water purification are treated as part of the full costs of operating the upstream factory.)

The private automobile is a similar case, but even more complicated, because each of a million cars contributes its small bit of the Los Angeles smog; each driver pays in coughs and tears, and perhaps lung disease, for everyone else's exhaust emissions, but his own responsibility is negligibly small.

We are used to these consequences of "external effects." I mean that we are accustomed to them as citizens; and we understand them as economists. But economists realize, as citizens sometimes do not, that the implications of external effects must be traced further. They have secondary effects on the system of resource allocation. If electric power is "too cheap" to the customer, because he is not charged with its full social cost, then other things will happen. Other commodities that are produced with the help of large amounts of electric power will also be cheap, and they will be overproduced. Other industries will be tempted to adopt techniques of production that use more electric power than they would if the price of electric power were higher. The rest of the society will find itself subsidizing those people—if they are an identifiable group—who consume a lot of electricity or a lot of goods made with a lot of electricity.

Similarly, if society is in fact subsidizing the private automobile—by not charging it for all the damage it does—then the location patterns of suburbs and of industry will be affected. A change in the private costs of automobile travel will have effects on house rents, residential choices, and eventually on the location of industry. If the use of DDT and other toxic chlorinated hydrocarbons were prohibited, or merely made more expensive, one would naturally expect certain changes in food prices and availability. But there might also be corresponding effects on the regional distribution of income and population, and these in turn might have further consequences difficult to calculate.

Piecemeal Regulation May Be Inefficient

The existence of all these systematic interdependencies means that piecemeal remedies for environmental pollution, by direct prohibitions and by setting specific standards for emission, may be inefficient and even harmful.

Piecemeal regulation may simply transfer pollution from one medium to another. For example, if the people of a densely populated city are denied the right to burn their trash in ordinary furnaces and incinerators, the city will have to find some other way to dispose of solid wastes; and this may be costly and difficult to do without spoiling the environment in other ways. New York and Philadelphia have tried to improve water quality by intensive municipal sewage treatment. One result has been the generation of a large volume of biologically active sludge. This is currently being carried out to sea in barges and dumped there, with unknown effects. To take another example, the scrubbing of stack gases can certainly reduce the emission of particle matter into the air; but it creates another liquid waste for disposal. One cannot know without a calculation whether the regulation of stack gases is in any particular case the right way to proceed.

The simplest way to deal with an acute pollution problem is to set minimum quality standards for air or water and enforce them on each polluter. But this ignores the fact that some sources of pollution are more readily remedied than others. If two factories producing different commodities both contaminate the same stream to the same extent, it might seem natural to require each of them to reduce its contamination by, say, 50 percent. If that were done, it would be almost certain that the incremental cost of a small further reduction would be different for the two factories; after all, they use different production techniques. But then it would be better if one of the factories—the one with the smaller incremental cost—were required to pollute still a little less, and the other permitted to pollute a little more. The total amount of pollution would be the same, but the total cost of accomplishing the 50 percent reduction would be smaller. Since it is the total amount of pollution that matters, the cheaper possibilities of reduction should be exploited first.

This would be accomplished if, instead of a direct imposition of standards, the two factories were charged or taxed an amount proportional to their emission of pollutants. The height of the tax could be varied until the desired total reduction in pollution occurred; the factories themselves would see to it that it occurred in the cheapest possible way. It is perfectly true that this way of doing things affects the distribution of income; the cost of preserving the environment is borne in a certain way. But that is true of any method, including simple prohibitions. The redistribution is only more visible in the case of a tax or effluent charge. The tax also provides some revenue which can be used either to further improve the environment or to assist genuine hardship cases or to accomplish socially desirable ends of any kind.

Here is a third example of the sort of mistake that can result from a piecemeal approach to policy. In the United States, it is often proposed that the government subsidize the construction of waste-treatment facilities. Only a few such proposals have worked their way into the law, usually indirectly. But why should the government promote the purchase of special equipment when other methods might be superior: the substitution of a cleaner fuel or other material for a dirtier one, or other changes in production methods, or the recirculation of cooling water, or the recovery of by-products for further use, or even the relocation of production altogether? I suppose the answer is that it is easier to subsidize treatment facilities: The amount is simply determined as a fraction of cost, and the industry that produces waste-treatment equipment is naturally anxious to have its product subsidized. Unfortunately, this may be an expensive way to accomplish the result, especially because, if the alternative to waste treatment is continued free dumping into the atmosphere or watercourse, the subsidy may have to be almost complete to induce polluters to take it.

Still another difficulty with piecemeal regulation is that it may be localized, in which case the environmental damage may simply be transferred to another town or district or region or—in Europe—another country. A sensible approach circumvents this possibility by having a unified regional policy, perhaps an international one.

A final difficulty with piecemeal policy is that it works automatically against large public investment projects in such fields as solid-waste disposal, low-flow augmentation in rivers, and perhaps others. It is not always the case that such large public investments are the best solution to a problem; but they are sometimes the best, and, when they are, this is unlikely to be discovered except as part of a system-wide analysis.

Use of Effluent Charges

In many cases, probably most cases, where direct regulation seems the natural approach to the concerned citizen, the economist will prefer to use taxes or effluent charges or user charges of some kind. I have mentioned one obvious reason for this: It is in the social interest that the cheapest method should be adopted to achieve any given reduction in pollution. A system of taxes and charges is more likely to accomplish this than direct regulation, given that we cannot possibly have all the desired facts.

This economizing on information is a second reason for favoring taxes over direct regulation. The construction of a good schedule of taxes or fees also requires information, but rather less information. And the process of collection itself produces new information that can be used to improve the schedule in use.

Third, financial incentives are usually easier to administer than direct regulation. They preserve decentralized decision-making, which is often good in itself, and in so doing they induce everyone directly concerned to seek for trade-offs and substitutions and improved techniques that could not be known to any central office.

I think it is also a good general principle that fees or taxes are better than subsidies. It is probably an unpopular principle—nobody likes a tax, but there is always at least one person who likes a subsidy. Subsidies, however, are more difficult to administer. A tax is levied against the amount of pollution actually discharged, an observable quantity. A correct subsidy depends on how much pollution has been reduced from what it would have been in the absence of the subsidy, a hypothetical quantity. If one subsidizes *actual* waste treatment, this may lead to the perverse result that techniques may be adopted that lead to the production of waste on an unnecessarily large scale, simply to collect the subsidy for treating it. Moreover, subsidies will lead to higher net profits in pollution-intensive industries, and perhaps attract a socially undesirable expansion of those industries.

Taxes are generally preferable to subsidies on grounds of equity, too. If some part of the population likes to do things or consume things whose production damages the national environment, it seems fairer that they should pay for the damage than that we should have to bribe them to stop.

This general principle may need to be modified, however, to the extent that the initial distribution of income in society is not equitable. If everyone had the same income, or if the distribution of income met some other standards of equity and justice, it would be right to say that anyone who indulges a taste that leads to the pollution of the environment should be required to pay the costs of restoring environmental quality, or at least to compensate others for the damage caused them.

But incomes are not equally distributed, nor do they meet any other test of equity or justice. The principle of assessing environmental costs on the activities that cause them would lead to material goods (which play a relatively bigger role in the budgets of the poor) becoming dearer relative to services (which play a proportionately bigger role in the budgets of the rich). It might lead to the taxation of the necessities of life of the poor to pay for the protection of the recreational amenities of the rich. There is not much to be said for that.

The economist's answer is that two wrongs don't usually make a right. It is irrational to befoul the environment by fudging a desirable system of taxes and user charges in order to accomplish redistributional aims. It would be far better to achieve an efficient allocation of resources by a proper system of effluent charges; and to correct an inequitable distribution of income and wealth directly by taxing the income and the wealth of the rich to subsidize the poor.

It hardly needs saying that there are situations in which immediate and decisive regulatory action is the only sensible thing. It seems very unlikely that we would ever regret simply having forbidden the disposal of heavy toxic metals like mercury or arsenic where they can be consumed by animals or humans. We may also want to stop irreversible deterioration of certain national resources at once. Formally, these are cases where the optimum taxes or user charges are prohibitive.

Even if it is granted that fees and taxes are generally preferable to specific regulations, that does not settle the matter. There is still need for a new and inclusive way of looking at the management of the physical environment as a natural resource which is common property. The usual textbook illustrations of external effects and their correction through bilateral negotiation or isolated fees and taxes are too simple, too isolated, too often artificially concerned with two parties who know each other, who realize how they interact, and who can negotiate a proper solution. At the present stage of economic development, something more serious is happening.

The Universal Problem of Materials Disposal

The leading specialist on these matters has remarked (*1*) that we need to take account of the fundamental physical law of the conservation of mass. Our language speaks of the "consumption" of goods as if nothing is left of them after they are consumed. But of course everything is left of them. Every ton of material that is removed from the earth and transformed into goods still remains to be disposed of when the goods in question are finally used. Sometimes, as in the case of a building or a dam, disposal is postponed for a very long time. But the fact that thousands of automobiles are abandoned on city streets, or even deposited in country streams to rust reminds us that durable goods are not permanent. It is also true that much of the weight of each year's production is transformed into gas and disposed of into the atmosphere without any special handling. This is especially true of fuels. But that is part of the problem; the capacity of the air to absorb waste gases is not limitless.

In principle, then, the residuals from production weigh as much (or slightly more) than the original weight of materials. All this has to be returned to the environment in one way or another, unless it is recycled. Even what we call "waste treatment" merely changes the form of waste material, presumably to something less unpleasant, but the disposal problem remains. This problem is growing in size along with the production of goods. It has been estimated (*2*) that the total weight of basic materials produced in (or imported into) the United States in 1963 was 2261 million tons (excluding construction materials, mine wastes, and other materials that are just moved from one place to another without undergoing any real chemical change). By 1965 the figure was 2492 million tons, 10 percent higher after 2 years. There is no reason to doubt that the figure is considerably higher now. Over half of this total weight consists of mineral fuels, which are discharged, more or less unnoticed, into the atmosphere as carbon dioxide and water vapor. This seems to have minor short-run effects though, as you know, there is now beginning to be some worry about the possible effects on climate of the accumulation of carbon dioxide in the atmosphere.

The point of my reference to the conservation of mass is that there is not an air pollution problem and a water pollution problem; there is a materials disposal problem. Some ways of disposing of materials are less objectionable than others, just as some materials are less objectionable than others. But one must keep in mind that to "eliminate" air and water pollution means to transform them into the problem of disposing of solid waste, another pollution problem. The only "solution" to the combined problem is the recycling of materials (or the greater durability of material things or the increased efficiency of conversion of fuels into energy). The rest is a choice of the socially best way to dispose of a given weight of residual material.

Since this combined problem is getting bigger, it must be planned for, and it is probably best planned for as a large-scale problem in managing the flow of materials. This suggests that planning must be at least regional and, in principle, concerned with all the media of waste disposal.

Nevertheless, there are certain real physical differences between water pollution and air pollution, and the physical differences mean that the best available policies are likely to be different. Water flows downhill, and there is a natural asymmetry between upstream and downstream. In most cases it is possible to identify natural boundaries to river basins or coastal estuaries, and to deal with them as more or less isolated units. One can more clearly identify individual polluters and individual victims of pollution, and they tend to be distinct individuals or groups (though, of course, B may be a victim of A's pollution and a polluter of C). I do not mean to make it sound excessively simple, as an outsider often tends to do; planning for a water basin is not simple. There are networks of streams and mixed possibilities of treatment of waste at source, treatment of waste still further downstream, mechanical reaeration, and low-flow augmentation. Still, I understand that there have been several successful attempts to build mathematical models of water systems with a view to planning for improved water quality, such as the Delaware River Basin in the eastern United States, the Miami River Basin in Ohio, and recently Jamaica Bay at New York City. I gather that these models are oversimplified, usually account for only one pollutant (biochemical oxygen demand) and only one measure of water quality (dissolved oxygen). An economist is used to oversimplified models, and is even encouraged by seeing that others have to use them too.

These models can be used to find solutions to planning problems of the following kind. What combination of waste treatment at each source and low-flow augmentation from a reservoir will maintain specified minimum water-quality standards throughout the river basin at least total cost? And what system of effluent charges or taxes on untreated wastes will induce the polluters themselves to achieve that socially best degree of waste treatment? The best system of effluent charges would vary by time of year and location on the river basin. In principle, it ought to be possible to use the model to determine the appropriate minimum water-quality standards themselves, but for that one must know something about the actual damage caused by specified amounts of stream pollution. I will come back to that question.

I have mentioned the economist's tendency to prefer taxes or effluent charges to direct regulation or subsidies as a device for environmental planning. Let me emphasize again the reasons for this choice in this water-quality context. In the first place, effluent charges concentrate automatically on the cheap abatement of pollution, rather than on any artificial allocation of the abatement burden on polluters. For the same reason, effluent charges provide an incentive for the polluters themselves to search for new and cheaper methods of waste treatment and waste reduction including changes in their own production methods. Finally, effluent charges allow for a certain amount of decentralized decision-making. This is valuable for its own sake, and because it economizes on information, especially on information in the hands of the central authority controlling the river basin. It does not economize completely: intelligent management of water quality requires that the central authority have a lot of information about characteristics of stream flow and about the social costs of poor water quality. Individual polluters are likely to know most about the costs of reducing pollution at their own locations.

It seems to be possible to adapt the principles of two-level iterative planning that have been developed in Hungary and elsewhere for general purposes to the specific problem of water management. One such procedure (*3*) requires the central authority to propose a scale of effluent charges to each polluter. Each polluter then makes his own cost calculation and responds to the central authority by reporting the amount of pollution he will discharge into the river and his total spending on purification. Using this information, the central authority calculates a new schedule of effluent charges. The procedure continues in this way until it converges to the optimum schedule of charges and the least-cost combination of treatments satisfying the minimum standards.

Such a system collects revenue, almost as a by-product of environmental policy, because the main function of the taxes is to induce polluters to do the socially optimum thing. But the revenues can be used for any good cause. In particular, the best policy for managing a river basin may well involve the construction of some large-scale public investments, like reservoirs or downstream treatment facilities. The revenue from the effluent charges can be applied toward the cost of these public investments. Some part might also be used to assist workers in marginal enterprises made unprofitable by the taxes to find new jobs elsewhere.

Air pollution, especially in large cities, is in some important physical respects different from water pollution. Obviously the air moves less predictably as compared to water. Meteorologists can and do make mathematical models of the atmosphere, but they cannot capture local and short-run events. Moreover, the number of actual and potential polluters of the air is usually much larger than the number of waste sources along a watercourse. Air pollution is rather like automobile congestion. Just as each driver in a traffic jam is inflicting delay costs on every other driver (as well as himself), so is every polluter of the air in a city polluting everyone else (including himself), and inflicting costs on the property and the health of everyone else. The analogy to automobile congestion is interesting also because automobile exhaust emissions are such an important contributor to the pollution problem in large cities.

For this reason, it is much more difficult to imagine optimum planning of pollution abatement in a city than to imagine it in a river basin. A system of effluent charges would involve metering altogether too many emissions: from industrial stacks, from domestic heating, from automobiles, from office buildings, and from public utilities, Moreover, the seriousness of air pollution often depends on photochemical reactions in the atmosphere which cannot be directly connected with any particular polluter. The best solution may involve metering the few very large polluters and treating the many small ones differently.

Even apart from these difficulties of measurement, urban air pollution presents difficulties because it could be inefficient to treat it in isolation from other modes of waste disposal. A city could easily clean its air by disposing of most of its wastes in water; or it could just as easily protect its water by concentrating its wastes and incinerating the residues. Nor can the burden be thrown entirely on solid-waste disposal, because that has become an equally costly and difficult process in most areas of dense population. Rational management of waste materials in a city will require something more complicated than a model of a single river basin.

Shortcuts and a Possible Systematic Scheme

It is probably possible to make some progress by using shortcuts, though this may often cause a certain amount of inefficiency and inequity. For example, major polluters of the air, like electricity-generating stations, can be metered and regulated or taxed. It would seem much easier to control sulfur emission by the mass of small users by regulating instead the small number of refiners of oil, preferably by a system of excise taxes based on the sulfur content of oil sold. Similarly, although it might be prohibitively expensive to meter the exhausts of individual automobiles, it is obviously possible to tax gasoline (perhaps at different rates according to lead content, octane rating, and such) or to require pollution-control devices on newly produced cars, as we now intend. These shortcuts have disadvantages. They tax a particular fuel or device rather than the thing that ought ideally to be taxed, namely, pollution itself, but they are clearly much better than doing nothing at all.

The interrelations of air pollution, water pollution, solid-waste disposal, sewage, old automobiles, plastic containers, and all the other paraphernalia of life in a high-income city remind us again that the whole problem really boils down to the general one of managing the material residuals of production. Mills has recently proposed a scheme that is worth describing, if not as an immediately practical proposal then as one leading in the right direction (*4*). In principle, this proposal is that the government collect a materials-use fee on specified materials removed from the environment. The fee would have to be paid by the original producer or importer of raw materials. It would be set for each material to equal the social cost to the environment if the material were eventually returned to the environment in the most harmful way possible. The fees would be refunded to anyone who could certify that he had disposed of the material, with the size of the refund depending on the method of disposal. Recycled materials would be exempt from the materials-use fee, which is equivalent to a full refund; disposal in a preferred way, relatively harmless to users of the environment, would earn a large refund; disposal in some moderately harmful way would earn a moderate refund; and disposal in the most harmful way would earn no refund at all.

The economic advantage of such a scheme is that whenever two or more materials can serve the same purpose—for example, biodegradable and nonbiodegradable materials for containers or detergents—the fees would make their prices reflect social costs, including disposal, rather than merely private costs. The original choices of materials would come nearer to being socially optimum. To the extent that the schedule of refunds were an accurate reflection of the social costs of various methods of disposal, they would provide a correct guide to individuals and private and public agencies in choosing a method of disposal in view of the direct costs and the accompanying refund. There is also an administrative advantage in such a scheme: it avoids the worst measurement problems. For many important materials, fuels, for instance, it is fairly easy to measure the amount removed from the earth by the first producer. It is much harder to measure disposal by various methods, but here the burden of proof is placed on the individual, not on the pollution-control agency. In order to receive a refund, the individual must demonstrate that he has disposed of so much of the material by a relatively harmless method. One can easily imagine specialized firms springing up to perform disposal services and to provide certification of the method of disposal.

There are, of course, difficulties with any such scheme. It would have to apply over a wide geographic area, or else one place would be making refunds to those who disposed of materials that had paid the fee elsewhere—this adds insult to injury for the area serving as a dump. There would have to be some sort of price correction for materials incorporated in very durable objects; and the scheme would hardly work at all for materials incorporated in essentially permanent objects like buildings, which, perhaps, should be thought of as harmless disposal, entitled to a full refund. There would be problems of equity. Owners of deposits of certain materials would suffer an immediate capital loss if such a fee were legislated. For some materials it would be nearly impossible to detect their first removal from the environment or to verify the method of disposal.

Practical or not, the scheme has great merit, I think, if only because it puts the problem in the right setting—namely, the global materials balance—and characterizes it in the right way, in that it depends on a price system with a centralized correction for the divergence between private and social costs. In some form, it might be the only way of making a generalized attack on air pollution. Even if it cannot be done, it is a good guide to thinking.

Like any good guide to thinking, it points to gaps in our knowledge. I mentioned earlier that one of the advantages in using the price system to control pollution is that it economizes on centralized information. I also mentioned that any approach to an optimum environmental policy necessarily requires a certain amount of centralized information, and more than we are accustomed to having. It appears to be the case that we actually know very little about the damage costs of stream pollution and air pollution, and thus know very little about the standards of environmental quality at which our society should aim. If we are to begin routine pricing of our common-property environmental resources, which is probably a necessary development, we need to know much more than we do about the effects on health of various common pollutants. At the moment the main source of information is from statistical analysis of epidemiological data—scattered data at that (*5*). We need to know more than we do about the effects of air pollutants on the performance and lifetime of metal and other surfaces exposed to the air. We need to have some way of estimating the damage costs of stream pollution, including the value of lost recreational opportunities. We may even need to have some agreed way of putting a monetary value on clean buildings and unspoiled landscape. We must even estimate how many more people would wish to look at unspoiled landscape if we had more of it to look at. These sound like vague and almost foolish tasks, but we must take them seriously if we take our physical environment seriously.

There is also, I gather, much room for improvement in models of the circulation of water in river basins and coastal estuaries, and especially in models of atmospheric diffusion. Economists have little or nothing to contribute directly to this effort; but they may be indirectly helpful to the extent that the object is to construct models that illuminate the strategically important interactions of the physical environment and the economic system itself. What is meteorologically or hydrologically interesting need not coincide with what is economically important.

It is possible that here, at last, is a natural place for interdisciplinary work between the natural and social sciences. It would be very nice if, together, we could contribute a rational solution to a problem that concerns us all.

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NEWS AND COMMENT

Narcotic Antagonists: New Methods to Treat Heroin Addiction

The rising incidence of heroin addiction and the generally discouraging record of attempts to rehabilitate addicts has fostered the hope that modern chemical wizardry will provide some means of inoculating addicts or potential addicts against the effects of heroin, thereby preventing drug addiction. But if a drug to block heroin addiction could be developed, to what extent would it help solve the drug problem, and would it be beneficial, to the addict and to society, to administer it?

The questions are not hypothetical, because such drugs, known as narcotic antagonists, do exist; but neither are the answers obvious. Skeptics who doubt the clinical effectiveness of narcotic antagonists point out that drug addiction is a behavioral response to deep-seated emotional problems, and that administering yet another drug to "cure" those problems is a naïve and simplistic approach. Others think that blocking heroin use with the antagonists will only cause addicts to switch to different drugs and will leave untouched the deeper problem of drug-seeking behavior. Those who have used narcotic antagonists in treatment do not promote them as a cure for addiction, but they do believe that these drugs can be a useful adjunct to psychotherapy and a significant means of preventing heroin addiction, especially among adolescents. The whole issue is likely to receive much more attention; President Nixon's newly appointed coordinator for drug abuse prevention, Jerome Jaffe, has included antagonists on his list of potentially important treatment options. Funding for research on these drugs will apparently increase.

Narcotic antagonists are effective against heroin and other narcotics because they prevent those drugs from reaching the nervous system; antagonists differ, for example, from methadone, a synthetic narcotic, in that they themselves do not have narcotic effects and are not addictive.

The two narcotic antagonists now being used in experimental treatment programs are cyclazocine (a benzomorphine compound) and naloxone (*N*-allylnoroxymorphone). A daily dose of about 4 milligrams, given orally, of cyclazocine, which is the more widely used, will block both the habituating effects and the euphoria, or "high," from heroin for 24 hours. Patients are built up to this blocking dose gradually over a period of several weeks and in the early stages often experience dizziness, headaches, and other side effects—sometimes including hallucinations. Once established on the blocking dose, patients who miss their daily dose report experiencing headaches and sensations akin to "electric shocks." At two and three times the doses normally used in treatment, cyclazocine apparently can have an effect similar to LSD, only more unpleasant. Cyclazocine is slightly habituating, in the sense that mild withdrawal symptoms (the electric shocks) occur when its usage is discontinued; but neither it nor naloxone is addictive. The narcotic antagonists, unlike methadone, do not satisfy an addict's craving for drugs, and, despite side effects, treatment with these drugs is for the addict very much like being drug-free. In fact, many former addicts reportedly test the antagonist from time to time by injecting heroin, because they "don't feel anything" with the antagonist.

Naloxone has far fewer side effects than cyclazocine and apparently does not require a period of gradual accommodation. Pharmacologically, it is in many ways an almost perfect antagonist. It can be used to treat heroin overdose and has been licensed for this purpose by the Food and Drug Administration; * recovery from the effects of heroin overdose usually begins within a few minutes after naloxone is injected.

* Neither cyclazocine nor naloxone has been approved for the treatment of addiction, and both are available for this purpose as investigative drugs only.