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EXPERIMENTS IN THE SOCIAL SCIENCES[1]

By PROFESSOR HAROLD F. CLARK

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CAN you experiment in the social sciences? With the help of the Sloan Foundation and several universities, I have had the chance to try to get a partial answer to the question. What have we learned from these efforts regarding the limits of experimentation in the social sciences? Does experimentation offer any promise of throwing light on complicated social problems? Before we turn to our efforts at experimenting let us briefly review something of the history of science and see if we can obtain any light on the problem.

Animals hibernate in the mud at the bottom of streams in the winter. That is obvious; the animal is here in the fall, he is here in the spring. He must have gone in the mud. At least some of the greatest minds in the world said so only a little over two thousand years ago.

Every one knows that the way to cure a person of witches curse is to rub his head with ground-up bodies of dried wasps. So, at least, said some of the great medical authorities of the middle ages.

Rosen, in his recent book on "Hollywood," says many of the famous actors and actresses believe in the magic of numbers. One particular actor would never go on the stage unless the number of steps was exactly nine. He knew he would hurt himself if it was any other number. One day the studio built a set with ten steps on it. The actor insisted the steps be changed to nine. They were. That day he fell down

[1] Address of the vice-president and chairman of Section Q—Education, American Association for the Advancement of Science, Cleveland, Ohio, September 12, 1944.

the steps and broke his arm. He said, "See if they had not changed those steps, I would have broken my neck."

The progress of the extension of scientific attitudes is slow and difficult. Watching its extension is one of the most interesting of all intellectual activities. The people of any age in the past have been willing to adopt scientific methods and use science in helping solve only a small fraction of their problems.

There are many ways to indicate this slow expansion of the scientific attitude. One is to look at the great scientific organizations and see the expansion of topics covered in their programs and articles. The Royal Society of London is one of the oldest and greatest scientific organizations in the world. What has it discussed during this long history?

There was little or no attention to social problems or to the social effects of science in the early centuries of the organization. I have not read all the articles in the publications of the society. The index, however, shows that few if any articles were dealing with social problems in the early years. I went through the volumes with care, and if there was any indication from the index that an article had social implications, I turned to the article itself. What range of topics did I find discussed?

When the Royal Society was established, its conception of science was pretty largely limited to the physical world. In the general index to the Philosophical Transactions of the Royal Society, volumes 1 to 70, we find no reference to what we could call social problems, as such, and certainly nothing remotely resembling experimental procedure in any of the social fields. In fact, the index is particularly interesting because it indicates that social problems were not considered as being subject to scientific procedure. The words in the index just before and just after the place "social" would appear are of more than passing interest. The words appear in the index in this order:

soak
Social war [just to ease your minds, however, "social war" does not refer to warfare among social classes, but the article to which it refers has the following interesting title:
"Elucidation of an Etruscan Coin Emitted from the Mint There about the Time of the Social War."]
soil
Solanum Lethale

So, we can see clearly there is not reference to social problems to society or to any similar words.

If we turn to the heading "Man," we do not find much more to indicate an interest in social problems. There are several articles appearing under the heading "Man." The first article has this odd title, "Account of a Man of a Strangely Interesting Nature." The next article is even more astounding. "The Anatomy of a Decrepid Old Man of 109 Years." You may use your own skepticism regarding the next title, but it actually appears as a paper in the Transactions of the Royal Society, "Letter Concerning a Man Who Lived 18 Years on Water." The next entry under the heading "Man" is "Extract of a Letter Concerning Two Men of an Extraordinary Bulk and Weight, An Essay Toward Ascertaining Specific Gravity of Living Man."

These are papers that appeared during the period of seventy years in the Transactions of the Royal Society concerning man. Any other headings that might indicate a social orientation of articles produce much the same result. I think it is safe to say that the Royal Society in the first seventy years of its existence was so absorbed in trying to extend science in the physical fields that it had little time to deal with social problems. This is no criticism of the Royal Society and its distinguished members, but simply is another indication of the slowness with which the scientific approach extends into new fields.

If we take the period from 1781 to 1820, our results will be much the same. The index of the Philosophical Transactions of the Royal Society covering this period of approximately a generation gives no word at all where "social" would appear in the index. First the word "Sobieski" appears; "social" would appear next, but there is no entry under this heading. The next word in the index is "soda," the next "sodium." Such words as "society," "humanity," "man" failed to produce any articles that could remotely be called social in their application.

The volume of the index covering the period 1821–1830 lists the word "snipe," the next word is "soda." "Social" does not appear at all. I think it is safe to say that the papers reported in the Transactions of the Royal Society in the early part of the last century had not yet reached the stage of dealing with what we would call the major social problems. Science was still engaged in expanding its field in the physical world, and again this is no criticism. It is difficult to see how any other alternative would have been possible at the time.

The curious thing is that as a hundred years are passed over, and we take the early volumes of this century, exactly the same situation will be found to exist. In the Royal Society Catalogue of Scientific Papers Index to the "Proceedings of the Royal Society of London, 1905–1930" there is no reference to social or society. The index contains the word "snow" and the next word is "Soddy." A study of such headings as "man," "humanity" and similar words also indicates that papers dealing with what we would call the social sciences were not included.

Of course, I am not implying that long before this there had not been the rise of other organizations in England that were taking a scientific approach to the study of human and social problems. But it is of more than passing interest that seemingly the Royal Society paid little attention to such problems even in as recent a period as 1901–1930.

In the 1930's, we find scientific organizations all over the world taking a far more active position toward extending the scientific attitude into social and economic fields. This was due, in some part at least, to the attacks that were made on science, by some inaccurately informed individuals. But even more, I think it indicates further extension in the slow process of expanding scientific techniques into additional fields. This may turn out to be the most helpful and important thing that has happened in our day and generation. Special societies were organized early in the nineteenth century which tried to get a more scientific approach to human and social problems.

Seemingly, many of the great and powerful scientific organizations were slow to expand their activities to include the social field. By the end of the first third of the twentieth century, it was crystal clear that such expansion must take place. This extension is necessary both for the safety of society and the further growth and expansion of science itself. In the 1930's, we have both the great British and American scientific associations going on record officially as saying that organizations of scientists must devote systematic attention to the social problems around us. The scientist knows better than any one else that only the systematic and careful study of social problems can possibly provide a dependable answer as to the method of solving such problems.

The rest of this paper will be devoted largely to an effort to try to indicate some of the methods by which science can expand into the social fields. One illustration will be discussed at some length to show that there are even much wider ranges of experimental possibilities than have been seen by most people in the past.

Should scientific techniques be extended to the social field? Many will say it should not be tried. Others will say it can't be done. Still others will say that the problems are so difficult that it is impossible to isolate individual factors and find their influence.

It is always difficult to move scientific investigation into new fields. If it were not difficult, the Greeks, the Romans, the people in the Middle Ages or even those living in Hollywood would have done something about it.

Some birds and animals are here in the fall, gone in the winter, here in the spring. Some of the greatest minds of Greece could not figure out what had happened.

People do not like to reach the wrong answer on this or any other problem just for the sake of having them wrong. If they get the wrong answer it is because they do not know how to get the right one. After the problem is solved, it always looks easy. Electric lights look very simple to us, but more than one man was called crazy when trying to make them.

For thousands of years the extension of the scientific attitude into new areas has gone on. Prehistoric man was not sure what happened when seeds were planted. A few seeds went into the ground; many seeds appeared in the plants. The gods had intervened in human affairs for man's benefit. Primitive man did not understand what had happened. He gave some kind of magic credit for the result and let it go. Some of our ancestors argued it was magic and insisted that the gods would be offended if investigations were made. Some argued that it was wise to investigate and see what made the seeds grow. It was only after many centuries that the investigators won and the grain and crops were improved.

A recent "History of Bread" tells us that for long centuries in Egypt the making of bread was a mysterious art. The sacred dough to make bread rise was kept as carefully as the sacred fires. It was many generations before man dared investigate the cause of the bread rising, but finally he did. Better and cheaper bread resulted.

After many thousands of years, it became respectable to study scientifically the causes of the sprouting of grain, the growth of plants, the life cycle of animals. Much of the physical world could be investigated directly. For some thousands of years then man has been willing to investigate certain parts of the biological world. In the nineteenth and twentieth centuries, man has been willing to investigate scientifically a small part of the social and economic world.

We are speaking of science as opposed to magic, superstition and untested ways of doing things. Science is not opposed to common sense, but it is an effort to check results of common sense in every way possible. The order of investigation might be as follows: the results of common sense, careful observation, then controlled experimentation.

Obviously, this is not always the sequence of events. In astronomy, for instance, experimentation is severely limited. No one has yet been able to make a solar system to match and serve as a control to the observed one, and yet astronomy has been able to produce work of the greatest scientific importance.

Experiments are a great help if you can get them. If it is impossible to experiment, there are many other ingenious ways to proceed to get more scientific results than man has previously had. How then would we expect to broaden scientific technique into the social and human fields?

The following illustration may throw some light on the problem; Because of observed results in certain communities in Texas, many dentists and doctors have been led to believe that a small amount of fluorine in the water will retard or possibly even stop the decay of teeth. Dentists might argue about this for generations. The obvious thing to do is to attempt to get experimental evidence but how can you experiment upon a community? Seemingly, it is not too difficult once the decision is made to try it. The experiment has been set up and is being tried over a period of ten years in two cities in New York State. Newburgh and Kingston, two small cities of about the same population, have been chosen. These two cities of approximately the same size and population have much the same social and economic pattern, and both are in the Hudson River Valley and presumably would have the same general factors affecting the teeth of the populations.

In one city fluorine is to be put in the water. In the other it will not be put in. Will the teeth be better in the community that has the fluorine in the water? This seems like the only sensible way to try to get an answer to the problem—set up an experiment and see what happens.

It is quite true that there are literally thousands of unknown factors that work in both communities. The scientist accustomed to working in the physical laboratory with what he called a controlled experiment would be appalled at the uncontrolled factors in this situation. No one would maintain that this is a perfectly constructed experiment. No one would maintain that it would finally answer the question. If the experiments are repeated in a dozen other communities with a dozen other controls in various sections of the country, and the results always turn out the same, it would probably shed a great deal of light upon the problem. There are an enormous number of social and economic problems that could be experimented upon in exactly the same way. Experimental and controlled communities could be chosen and the experiment carried on.

Does the study of mathematics discipline the mind of the person that studies it? Some say "yes" and some say "no." Some of the world's greatest mathematicians who are most careful in their own field, jump to conclusions when they discuss such a problem as this. They do not use the scientific method. Isn't the sensible way to answer the problem to set up an experiment and try to find out? This, of course, has been done. You may not be able to control all the factors, but if wise men carry on the experiment, men who use the best common sense and the most careful observation, you will get a better answer than will equally wise men with only common-sense plus observation.

In the social fields there are so many variables that you can not be sure of causal factors. Is that not reason for more experiments rather than trying to guess? I would like to illustrate by one problem how it is possible to set up an experiment to try to throw some light on an important social and economic problem. I am going to discuss the illustration at length because I believe it is possible to extend the technique to help solve thousands of our most pressing social and economic problems.

Here is a low-income, rural community. The diet is inadequate. Is the poor diet due to the fact that the people are too shiftless to make an effort to improve the diet or is it due to the fact that they do not know what to do? I can find you plenty of learned discussion in the best tradition of the witch doctor arguing that the people are lazy. I can find other equally good arguments maintaining that the problem is ignorance. Is the wise thing to go on discussing the problem forever, or can we get some experimental evidence?

Much of the land in this community is hilly. The farms are badly eroded. Much of the top soil had washed away. As soon as the people were shown how to improve these conditions they made changes. In one community, entirely agricultural, almost no poultry was raised although it was a very good place for raising it. Would the people raise chickens if they were given adequate instructions? The State Experiment Station bulletins and county agent were there to give them the information, so the answer must be that lack of information was not the reason. But the bulletins were too difficult to read and the county agent went only where he was asked. Could simpler material than the bulletin be prepared and would it be used? The only way to get the correct answer was to try and see.

A series of bulletins at the first-, second- and third-grade levels were prepared on gardens. Improvement and expansion occurred in many gardens. Some one will say that other factors were at work during this period trying to improve gardens. How do you know that your school instruction and readers made the change? The obvious way to answer the problem is to set up controlled experiments. This is difficult but no reason for not doing it. That is exactly what we did. We found one experimental community. Then we looked for a control community as nearly like it as possible. We wanted two communities of the same general economic status, same educational level, same racial stock, same age distribution, same religious and cultural beliefs. In other words, we wanted two communities as nearly alike as possible.

If the diet improves in the experimental community the new education program might have caused

the change. On the other hand, the diet might have improved in the control communities. Many factors might have been working on a state or nation-wide basis. If the diet improved more in the experimental community than in the control community, presumably our education material caused the difference.

Chance factors may still be the real cause. To answer this objection, we took a second experimental and second control community. If the second experimental community improved more than the second control community then the evidence is very strong.

Maybe there were local factors working here that would not be at work in the other sections of the country. The way to answer this problem was to take another set of control communities and another set of experimental communities in a different section of the country.

Perhaps the schools could improve diet. Could they improve any other important area of living? The way to find out whether schools could improve another area was to try it. For this additional part of the experiment the problem of housing was chosen. If we teach people in low-income communities how to improve their housing, will housing improve? That has been debated for centuries and the debate may go on for other centuries. The only sensible thing to do was to try it and see what happened. Steps were repaired, screens were fixed, gardens planted with trees and flowers, houses were painted, chimneys repaired, holes in roofs were stopped. The evidence seems impressive that if you show people how to improve their homes, they will do so.

Experimental communities changed. Control communities did not change as much. The evidence is strong that the education caused the change.

If the housing information were made available in a second community what would happen. Would housing conditions improve? If the information would improve conditions only in one community, the effort would hardly be worthwhile from the standpoint of the Sloan Foundation or society at large. Would the same results happen in a second and third community? Try it and see. It is the only way to be sure. It was tried in a second and third set of communities, experimental and control.

If you took the problem of clothing and tried the experiment in another section of the country, would conditions in low-income communities improve if they knew what to do? The scientific answer would be to try it and see. A conservative New England state was chosen. The evidence seems to be that the people will make a long series of improvements if they know what to do.

In regard to food, clothing and housing in three different sections of the country in various low-income communities, if people are told what to do to improve conditions they are ready and willing to make a wide variety of improvements. One hesitates to generalize too much on the evidence. But within the limits of this evidence, and it is rather broad, it does seem that low-income communities can and will improve themselves if they are shown how. What are the limits? Only further experimentation can tell.

Such experiments are expensive. That may be one reason so few of them have been carried on. This series of experiments have cost the Sloan Foundation a very large amount of money. But in terms of the hundred of millions and even billions that have been spent and the other billions that will be spent to aid low-income communities, the amount is trivial. Eighty or 90 per cent. of all the population of the world live in communities of lower economic standards than our experimental communities. The United States in the next five years will doubtless extend many billions of dollars of relief to various sections of the world. I would be the last to object to this. Many persons believe that the way we will extend the relief will leave the communities in essentially the same conditions as they were. A tiny fraction of this amount if spent in helping the people to find out far more adequate ways to help themselves seemingly would produce profound and permanent changes.

In the normal course of human developments there probably will be future occasions in this country when extremely large sums will be extended for relief. Seemingly great results could be attained if the people were really shown how to help themselves. This help, of course, has to be in terms of their own environment—things they can do and things that are within their experience.

The immediate practical results of the experiments seem to be important. They may be of far greater importance in indicating more clearly than has formerly been done the desirability of extending the scientific method into other fields of human activity. It seems reasonable to say that large-scale experimentation is possible in the social sciences and that such experiments should be greatly expanded.

I will refer very briefly to other types of experiments that could be carried on. Some people advocate one method of setting up a health program in a community. Other people advocate another method of setting up a health program. Why not set up both types of programs in comparable communities and attempt to show results in terms of actual community change? Any number of suggestions are being made to deal with the problem of juvenile delinquency. Why not try out the various methods and see which of them produces the best results? Various schemes of organizing school boards of collecting local taxes are advocated. Try out the various methods, keeping an accurate record of the results and make your de-

cisions on the basis of the facts. County school boards can be set up on various bases, which will give the best results.

Some years ago I made the suggestion to the governor of one of our progressive states that every county in the state should be carrying on some kind of carefully controlled experiments to answer the problems of public administration, governmental organization, public health and education of that state. If the proper kind of arrangements were made, this could be done with relatively small expense. The results should be enormous in terms of human welfare. Every community in the state would know that it was a part of some broad social experiment attempting to give the answer to public problems. A great deal of volunteer effort of young people from school and other groups could be obtained. The time might easily come when a community would pride itself more on the type of scientific experiments in the social field which are carried on than it would in its size or wealth.

It is quite true that we can not experiment in the social sciences in the narrow and rigid way that the laboratory scientist does, but we can experiment most usefully. The various parts of the Sloan experiment have thrown great light upon the problem of the effect of school instruction on changing food, clothing or housing in a low-income community. If the experiment is repeated in a great variety of forms and places, we should be able in a few generations to build up a far more accurate picture than any one now has of the effect of school instruction in changing a community. The experimental results available should make us very optimistic of the possibilities of extending scientific procedures into social problems. We can experiment in the social sciences with great profit to mankind.

TRANSLOCATION OF CARBOHYDRATES IN MAIZE[1]

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IT has been the aim of a large group of plant physiologists, with whom the writer likes to identify himself, to reduce the reactions and responses of living plants to processes demonstrable in our laboratory test-tubes. The evaporation of water from leaves, the absorption of water by roots and the diffusion of carbon dioxide through stomates are processes which we think we can soon, if not now, explain in terms of thermodynamics and the calculus. The tremendous strides of the last decade lead us to hope that we will be able eventually to explain photoperiodism, respiration and photosynthesis in terms of specific physico-chemical reactions. I think that we can see glimmerings of a similar basis for such vitalistic processes as protoplasm synthesis and the physiology of inheritance, but I confess myself baffled by some of the phenomena of translocation in plants.

The problem of the translocation of organic compounds in plants can be divided into the sub-problems of (a) the tissues concerned, (b) the compounds moved, (c) the mechanisms involved and (d) the controlling factors.

THE TISSUES CONCERNED

The experiments of Curtis[2] and of Mason[3] are generally considered to have established the phloem as the primary tissue of translocation. The maize plant with its many closed bundles is not adapted to studies of tissue function by ringing, etc., but we may assume that here, as in sumac, privet and cotton, the phloem is the important channel of food movement. The phloem of the stem, however, is surrounded by parenchyma and can not be studied separately. Our first task, therefore, has been to show that sugars are transferred between the phloem and the pith parenchyma, and that an analysis of the entire pith is capable of furnishing information on the progress of translocation. Such evidence has been obtained by covering plants growing in the field with light-tight covers and analyzing their tissues at intervals.

Typical data from one of these experiments are shown in Table 1. Ear shoot development was pro-

TABLE 1

CHANGES IN SUCROSE CONTENT OF TISSUES OF MAIZE PLANTS HELD IN DARKNESS

Tissue and stage	Sucrose, percentage of green weight			
	At start	After 24 hours	After 72 hours	Loss
Leaves				
Tasseling	2.42	0.11	0.11	2.31
Milk	2.65	0.20	0.13	2.52
Milk—bagged ..	2.30	0.46	0.76	1.54
Stalks				
Tasseling	0.59	0.22	0.26	0.33
Milk	8.54	6.20	5.03	3.51
Milk—bagged ..	8.01	7.38	7.19	0.82
Shanks				
Milk	5.42	4.25	3.07	2.35
Milk—bagged ..	3.88	3.70	3.10	0.78
Cobs				
Milk	2.32	2.19	2.39	−0.07
Milk—bagged ..	2.36	1.55	1.34	1.02

[1] Address of the retiring president (1943) of the American Society of Plant Physiologists, presented at the Cleveland meeting of the American Association for the Advancement of Science, Cleveland, Ohio, September, 1944.

[2] O. F. Curtis, "The Translocation of Solutes in Plants." New York. 1935.

[3] T. G. Mason and others. *Ann. Bot.*, 42: 189–253, 1928, and subsequent volumes.