Letters

Pioneering

How times have changed.

It's not that I am an old codger who actually can remember the Good Old Days. I am still a young man, so when I speak of contrasts, I have to rely on second-hand information. There is, of course, an added hazard in looking at things as they are today, because my view of the present is undoubtedly distorted by my own participation in it.

But, just the same, I keep comparing the situation of a young man in, say, 1870 who wanted to go homesteading on government land and the situation of a young person today who would like to get a piece of the "public domain" recently opened up in the name of research. I wonder if the comparison is really farfetched. In both cases the government is the patron and the prospective beneficiaries of its patronage have the pioneering instinct. Even the purposes behind the patronage are the same. Thus, we speak of "frontiers" in science and try to persuade young people to consider a scientific career by appealing to their spirit of adventure. We, too, have to open up the frontier before some rival power beats us to it. The analogy breaks down when we realize that part of the driving force behind earlier pioneering had something to do with individuals breaking away from a closed society "back East."

This is the way it might have been if yesterday's pioneer had had to put up with the way things are done today:

* * *

(Place: A government land office in the 1870's. A would-be homesteader enters.)

Clerk: Good morning. What can I do for you?

WBH: I would like to put in a homestead claim. I want to be a pioneer.

Clerk: Fine. But first we need some information, so that we can judge your qualifications. After all, we can't give away Government land to just anyone. This information, of course, will be confidential and will be reviewed by an impartial panel of Eminently Successful Pioneers. Now then, we need to know about your experience. Ever farm before?

WBH: Yes, I raised corn back in Illinois. I worked for another farmer.

Clerk: Were you successful?

WBH: Well, no . . . that is, not very. I thought I might try my luck at something new. Sort of go on my own.

Clerk: I see. Well, we would like to have you submit all of your records. We are especially interested in your productivity, so please include copies of your ledgers so that we may know how many bushels of corn you have produced in your farming career. Also, we would like to have your former employer back in Illinois submit an evaluation. Oh, and please fill out this form, telling us just what you intend to do with land if you get it. We shall need plans of the buildings you would erect, the method of farming you intend to use, evidence that this method will work, and a statement as to how your output of corn will contribute to the total corn picture in the infinite scheme of things.

WBH: But I plan to raise wheat.

Clerk: Oh. Well, it doesn't matter. But just between you and me, corn is currently the most rapidly advancing field.

WBH: When will I find out if I can have the land?

Clerk: The review panels meet three times a year to go over all the applications for homestead claims. I would allow 6 months for a decision. There is one more thing: We require that you sign this oath, stating that you do not now belong to, and never have belonged to, any organization which advocates taking land by force or violence and giving it to Indians.

(Place: The same government land office. Six months later.)

WBH: Well, do I get the land?

Clerk: I am sorry to inform you that, after careful review, the Homestead Bureau found that your application did not merit approval at this time. However, they will be pleased to receive another application from you in the future.

WBH: What was wrong with my application?

Clerk: Well, I'm really not supposed to give out information like that, but, confidentially, the review panel didn't approve of the way you planned to go about your pioneering program. One of them thought your wheat-growing plan was a little too much like one he's about to begin on his own place. Several felt that your land-clearing plans were extravagant for a beginning pioneer. I might add that your record didn't look too good, either. You really haven't had any experience in growing wheat, have you?

WBH: What do I do now?

Clerk: Perhaps I can interest you in a program instituted by the Eminently Successful Pioneers to help people get started in a career of pioneering. We call it a Pre-Pioneering Fellowship. In this program a young person like yourself can work with an Established Pioneer. This would give you a lot of pioneering experience. You would work on his place and help him produce a lot of whatever it is he is producing. Why, in no time at all, you too will become an Independent Pioneer—Wait a minute. Where are you going?

WBH: Back to Illinois. I'm going to ask that corn farmer if I can have my old job back.

Clerk: Shucks! He's gone. Oh, well, it's obvious he doesn't have the pioneering instinct anyway. They just don't make pioneers the way they used to. Why, in the old days . . .

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Historical Causality

In his review of Culbertson's book, *The Mind of Robots* (*1*), Householder is critical of "historical causality," or "action across a time lapse," which he defines as follows: "in the equations of motion of a dynamical system the derivatives of the six Newtonian coordinates for each element may depend not only upon the instantaneous values of these coordinates but, for a complete specification, may require knowledge of their values in the past." I assume that Householder is referring to dynamic

systems in general, and that by the "six Newtonian coordinates for each element" he means what control theorists call "state variables" (*2*, p. 14; *3*).

If this is correct, historical causality can be described in the following conventional notation. A dynamic system described by the causality relationship

$$\frac{dx_i}{dt} = f_i [\mathbf{x}(t), t] \qquad i = 1, 2, \ldots, n$$

(where **x** is the state vector and t is time) requires no "action across a time lapse." However, some systems can be described only by a relationship that includes hereditary influences

$$\frac{dx_i}{dt} = f_i [\mathbf{x}(t), t, \mathbf{x}(t-\tau)] \quad i = 1, 2, \ldots, n \quad \tau > 0$$

where dx_i/dt is a function of the past history of **x**. This latter type of system is mentioned in almost every text on modern control theory. For example, Bellman points out (*2*, p. 5) that every feedback control process falls into this latter category.

Therefore, Householder's professed belief that the principle of historical causality "has not been seriously considered in science" is incorrect. His further statement that "a vehicle for action across a time lapse seems hard to imagine" is difficult to understand because the well-known vehicle, memory, is pointed out by Householder himself later on in the review. In both the digital computer and the human being, action across a time lapse is the normal mode of operation, and memory is the mechanism by which this is accomplished.

Even the epiphenomenalism that apparently bothers Householder is familiar to control theorists. This arises from the arbitrariness of the state variables; in a complex system, it is seldom obvious what the optimum set of state variables is, and interpretation of experimental data or even simulations is often difficult.

It seems likely that Householder is intimately familiar with control theory and that an explanation exists for the apparent confusion in the review. However, if the review is to be useful, Householder must clarify his position.

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References and Notes

1. A. S. Householder, *Science* **141**, 895 (1963).
2. R. E. Bellman, *Adaptive Control Processes* (Princeton Univ. Press, Princeton, N.J., 1961).
3. Bellman defines the elements of the state vector as being that set of functions $[x_i(t)]$ containing all the information we will ever wish to have concerning the dynamic system.

I can assure Blakemore that I have some slight acquaintance with the literature on control theory and on the formal properties of differential-difference equations. In my review of Culbertson's book I was not concerned with the formal description of action across time. In ordinary applications of control theory the vehicle for this action is clearly present and well enough understood.

Culbertson himself seemed to feel that there was some novelty in the principle of historical causality, and the novelty lay just in the fact that no vehicle was provided. It explains nothing to talk about memory unless there is something there to store that which is remembered. The storage device in a digital computer is a perfectly definite part of the machine. The storage "device" in human beings is not too well understood, but presumably the storage is accomplished by physicochemical changes in the nerve cells. Culbertson is explicitly postulating some carry-over without use of the corresponding nerve cells, and the question at issue is how this comes about. Naturally we can, if we wish, just postulate that it takes place, and in accordance with such-and-such stated principles. We can do this, but I suspect that very few of us would find the procedure philosophically satisfying.

I regret that my language should have permitted such a basic misunderstanding of the main point I was trying to make.

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Detecting Insecticides in River Water

The recent report by Breidenbach and Lichtenberg [*Science* **141**, 900 (1963)] confirms the presence of DDT or dieldrin in river water at 14 of 101 locations. The method of extracting the insecticides from the water is carbon adsorption. Although the procedure used is adequate as a qualitative method, the inference is made that the lack of detection indicates an insecticide level of less than 1 μg per liter of water and that the amount observed in the case of positive tests indicates a level of 1 to 2 μg per liter of water. These allegations are based on a quantitative interpretation of the data which is not substantiated by either the experimental procedure or the references cited. The carbon adsorbate was prepared by passing the river water through a bed containing about 2 liters of activated carbon at a flow rate of 1.9 liters per minute. Up to 19,000 liters, or about 10,000 bed volumes, were used. Under these conditions of fast flow rate, granular carbon would be needed.

It is known that the efficiency of adsorption by activated carbon in a column decreases with decreasing bed depth, with increasing particle size, and with increasing flow rate. For high recovery of large organic molecules from solution with granular carbon, it has been my experience that flow rates of 1 bed volume each 20 minutes in columns containing a carbon bed 1 to 1½ m in depth are usually required. Less complete removal is obtained with faster flow rates and shorter columns. The adsorption condition of 1 bed volume per minute in a shallow (½ m) bed would undoubtedly give far from complete recovery of insecticides.

The low concentration also contributes to poor recovery of the insecticides, since under similar conditions of adsorption the percentage recovery decreases with decreasing concentration in the feed solution. This decrease, reflecting both adsorption and elution steps, is usually exponential. Although recovery experiments with the actual experimental conditions employed would be needed to determine the precise effect of concentration on the yield, the authors point out that DDT adsorption is 98 percent complete, and that 80 percent is eluted when an emulsion containing 5 mg per liter is used. This suggests that the recovery would be very poor indeed at concentrations of 1 to 2 μg per liter in the feed stream, since the residual concentration in the spent solution would be 100 μg per liter and the amount remaining on the carbon would be equivalent to 1000 μg per liter. Thus, rather than substantiating the sensitivity of the method, these data indicate the probability of low recovery and point out the need for further study.

Moreover, there is another serious objection to recovery estimates, and that is the effect of other substances which may be present in the water. Trace organic materials are present in any body of water, in contact with microorganisms, nutrients (both soluble and insoluble), and air. Some of these substances would be strongly ad-