(3), mounted in a bath of oxygenated Ringer-Locke solution.

Neuromuscular block was produced by intravenous injection of 10^8 mouse LD_{50}, or by addition of toxin to the muscle bath (10^3 to 5×10^4 mouse LD_{50}/ml bath fluid). Action potentials of either groups of muscle fibers or of single fibers were recorded from the surfaces of the muscles at an end plate region. The end plate region was located by applying decamethonium or curare and finding sites from which end plate potentials could be recorded. Toxin was administered after neuromuscular transmission had been restored.

Conduction in nerve trunks, or in muscle fibers that were stimulated directly, was not affected by the toxin. On the other hand, it could be shown that the constituent muscle fibers of a motor unit become inexcitable to stimulation through the nerve trunk one at a time, or in very small groups. It was found that the block produced by botulinum toxin in its early stages can be overcome by the second of two motor nerve volleys, separated by at least 0.8 msec. If botulinum toxin paralyzes by reducing the ACh-output at nerve endings, rather than by blocking conduction in motor terminals, then the second, successful volley should be preceded by an end plate potential in response to the first, unsuccessful volley. However, no end plate potentials could be recorded in response to the first volley when it failed to excite.

The above electrophysiological evidence suggested that action of the toxin is on the nerve filaments rather than on the mechanism of ACh-release. If that is true, stimulation of the nerve terminals resulting from the current that passes through the muscle during direct tetanization of the muscle should release the normal amount of ACh from a preparation that was paralyzed to nerve trunk stimulation by botulinum toxin. Measurements were therefore made of the ACh released by the guinea pig's excised diaphragm (a) during tetanization of the phrenic nerves, and (b) during direct stimulation of the muscle. Direct stimulation of the muscle released the same amount of ACh as indirect stimulation, of the same frequency and duration. Blocking doses of toxin prevented the release of ACh by nerve stimulation, but failed to alter the release by direct stimulation.

It is concluded that botulinum toxin (type A) produces neuromuscular paralysis by interfering with conduction in the terminal twigs of motor nerves, close to, or at, the points of final branching, but proximal to the site of ACh-release.

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Comments and Communications

Altman's Theory of Economic Cycles

IT is intriguing to find in a leading scientific journal a paper that treats the mysteries of economic cycles with such assurance and finality as to arrive at a "mathematically necessary result." The "mathematically necessary result" of George T. Altman's "Cycles in Economics and Nature," to be cited as "CiEaN" (SCIENCE, 115, 51 [1952]), means that the only way for the United States to escape repeated disastrous depressions is to change to socialism. Is such a conclusion justified?

Altmans theory, as elucidated with the aid of his book *Invisible Barrier* to be cited as "IB (Los Angeles: DeVorss & Co. [1949]), apparently runs as follows: In a particular country at a particular time, because of limitations imposed by manpower, natural resources, and the level of technological development, there is only a certain maximum amount of capital (v in CiEaN; C_θ in IB) that can be utilized efficiently. Capitalists, driven by the profit motive, periodically increase total invested capital (y in CiEaN; C in IB) till it becomes greater than v. This investment of "too much capital" causes the profit rate to fall. When the profit rate falls, capitalists sharply reduce investment, causing economic collapse. This reduction in rate of investment eventually causes y to become less than v. Consequently, profits rise, capitalists increase rate of investment, and another boom is on its way. These effects depend upon real, physical limitations on the use of capital and are not dependent upon speculative or inflationary value changes. The only satisfactory escape from recurrent cycles of boom-and-bust is to replace the profit motive by government control.

So runs the theory. In addition, Altman discusses in CiEaN a certain type of ecological system. His presentation of a single mathematical model supposed to fit both economic and ecological cycles may make it appear that the economic theory is based upon fundamental laws of nature applying to all living systems. I believe the appearance is illusory and that the ecological phenomena have no more to do with economic cycles than Newton's third law of motion has to do with rates of animal reproduction (see CiEaN, par. 9). For any of the numerous extant cycle theories, a mathematical model can be found, and it would be surprising if even one of these models should be without a counterpart in nature.

Let us consider four questions concerning Altman's theory.

1) *Do increases in total investment beyond "the capacity of the economy to utilize capital" cause decreases in profit rate?* Profit rate, as Altman employs it, is total profits divided by y, but y is taken not for the current year but for c (in CiEaN; t in IB) years earlier (IB, pp. 87, 145). Values of y (C) are tabulated on page 204 of IB for 1918 through 1947, and total corporate profits are tabulated by quarters for 1920 through 1938 in Barger's *Outlay and Income in the United States 1921–1938* (New York: National Bureau of Economic Research, 297 ff. [1942]). Since Altman does not specify an exact value for c, we cannot calculate exact profit rates. However, the fractional rate of change in total profits is so much greater than the fractional rate of change in y, that profit rate must be roughly proportional to total profits—whatever reasonable value we assume for c. Now, if investment ever was too great, it was surely so in the United States during the twenties, yet total corporate profits increased with extreme rapidity from 1927 on, reached a maximum in the third quarter of 1929, and were almost as high in the fourth quarter. The turning point marking the beginning of the Great Depression came in the second quarter of 1929, according to the most authoritative study yet made (Burns, A. F., and Mitchell, W. C. *Measuring Business Cycles*. New York: National Bureau of Economic Research, 78 [1946]). Thus it appears that a long period of "too much capital" resulted in an extraordinary rise in profit rate—although profit rates eventually fell after the depression was well under way.

2) *Is a fall in profit rate the usual cause of a decrease in investment?* According to G. H. Moore's study of "Statistical Indicators of Cyclical Revivals and Recessions" (National Bureau of Economic Research Occasional Paper 31, 64 [1950]), total corporate profits customarily pass through their peaks at about the same time as *general business activitiy*, whereas "new orders, durable goods industries," "residential building contracts," and "commercial and industrial building contracts" go through their peaks several months earlier. Thus it appears that decreases in the rate of investment usually *precede* decreases in profit rate.

3) *Does Altman's mathematical model fit observed economic behavior?* Neither in CiEaN nor in IB does Altman attempt to show that a fit can be obtained. Furthermore, there is good reason to think that a fit cannot be obtained. His equations (CiEaN, par. 8; IB, p. 160) are of sinusoidal form, and Burns and Mitchell (*op. cit.*, p. 157), after detailed study of 1277 economic series, concluded: "Chart 16 suggests, and our later monographs will demonstrate in detail, that there is little justification for the common notion that . . . a sine curve is a satisfactory 'approximation' or 'model' of the specific cycles found in experience."

4) *Does Altman's general theory quantitatively fit observed economic behavior?* According to Fig. 9 of IB, total invested capital (y or C) in the United States exceeded "the capacity of the economy to utilize capital" (v or C_θ) from about 1922 to 1942. During this period there were at least three complete business cycles (Burns and Mitchell, *op. cit.*, p, 78).

It seems to me that Altman has not proved his version of Marx' theory of economic cycles, and that to try to reduce economic cycles to a simple question of "too much capital" or "too little capital" is like trying to explain all of chemistry in terms of the four elements of the alchemists. What does actually cause economic cycles? Under private enterprise, levels of economic activity are obviously determined largely by decisions of entrepreneurs, and these decisions are based upon *expectations* of profits. Actual current profit levels are only one of many determinants of expectations, and they do not appear to be a crucially important one. Expectations are determined by all sorts of things, ranging from mathematically sophisticated extrapolations of past behavior, to communications from the spirit world relayed through the comic strip "Bringing Up Father" (see "From the Spirit's Mouth," *Newsweek*, pp. 60 ff. [Sept. 27, 1948]). And then the situation is further complicated by that common occupational disease of entrepreneurs, which might be named the Thompson syndrome:

Up vistaed hopes I sped;
And shot, precipitated,
Adown Titanic glooms of chasmèd fears—

In view of the labyrinthine ways of capitalist mentality, it seems improbable that any mathematically simple, single-cause theory of economic cycles can be successful.

With the publication of "Cycles in Economics and Nature" (using the pretext of being primarily interested in cycles in nature), SCIENCE has invaded the social sciences. I think this is all to the good, for such questions as whether socialism or capitalism is economically superior are of greater importance to most readers than are many of the questions considered in SCIENCE. Since economics is still at a developmental stage from which the natural sciences have largely emerged, it would be interesting to see in SCIENCE occasional examples of what contributions the natural sciences can make to economics. Perhaps such new tools as the operational definition can clarify old problems. Perhaps the time approaches for a new Boyle to produce a *Sceptical Economist*.

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MR. PRICE'S summary of my theory is substantially correct, but the word "periodically" comes a little early in his summary. The periodicity results from the excess of the rate of investment; it is not the direct, initial product of the profit motive. The excess of the rate of investment, in turn, results because there is no effective control of that rate except the profit or loss

realized, and that realization is not immediate but comes only after a lapse of time.

Mr. Price's only serious attack upon my theory is that it is not supported by statistical fact. His argument, however, is founded on an assumption shown by the original sources as completely false. I refer to his assumption that "the fractional rate of change in total profits is so much greater than the fractional rate of change in y, that profit rate must be roughly proportional to total profits."

TABLE 1*

	1928	1929	1930
Industries covered by Barger	5,066.0	5,952.0	1,663.6
Industries omitted by Barger	1,976.0	1,595.0	823.6
Total	7,042.0	1,547.0	840.0

* In millions of dollars. Source: *Statistical Abstract of the U. S.*, Table 189 (1931); Table 179 (1932); Table 181 (1933).

In the first place, the figures upon which Mr. Price relies for total profits, those of Harold Barger,[1] represent only corporate profits, whereas the figures upon which he relies for y are those of the invested capital of the entire economy.[2] In the second place, even the figures for corporate profits do not represent the profits of all corporations, but only those of certain classes of corporations. Trade, finance, and agricultural corporations are wholly omitted.[3] The seriousness of that error may be quickly seen in the data for "statutory net income" less taxes payable thereon (Table 1), "statutory net income" being net profits after excluding dividends received from domestic corporations and tax-exempt interest.

There is no objection, of course to the general mode of Mr. Price's inquiry. If statistics are available, my theory should be able to stand up to them. For this purpose I have developed Table 2. Prior year loss is not deducted; the dividends and interest excluded are as shown.

TABLE 2*

	1928	1929	1930
Industries covered by Barger			
Dividends	1,160.5	1,548.2	1,419.8
Interest	137.3	137.6	123.0
Industries omitted by Barger			
Dividends	756.5	1,044.8	1,151.2
Interest	455.7	398.4	413.0

* In millions of dollars. Source: Same as in Table 1.

The amounts shown for each first quarter in the first column of Table 2 were derived, for 1927 and subsequent years, from the asset and liability data tabulated from income tax returns and published in "Statistics of Income." Asset and liability data for prior

[1] *Outlay and Income in the United States 1921–1938*, New York: National Bureau of Economic Research, 297 ff., (1942).
[2] *Invisible Barrier*, p. 204.
[3] Barger. *Op. cit.*, p. 300, note c.

periods also appear in "Statistics of Income," but they are figures derived from capital stock tax returns, and in respect to total invested capital those returns are not adequately comparable with income tax returns, particularly because of the consolidated returns allowed for income taxes. Because of this fact, the figures for the first quarters of earlier years were developed by deducting, year by year, the annual amounts of reinvested earnings and stock issues for new capital.[4] The amounts for the second, third, and fourth quarters of each year were interpolated by means of percentages composed to the extent of $\frac{5}{8}$ from the quarterly distribution of new capital issues[5] and $\frac{3}{8}$ from Barger's quarterly distribution of earnings, the respective weights of $\frac{5}{8}$ and $\frac{3}{8}$ giving effect very roughly to the relative weights of new capital and reinvested earnings in the growth of corporate capital.

These figures contain, it is true, two substantial flaws. The stock issues for new capital used in deriving the pre-1927 figures represent only public issues. That flaw, however, greatly reduces the increase in the figures from year to year and is therefore an error in Mr. Price's favor. The other flaw is that the figures taken from "Statistics of Income" for the years 1927–29, inclusive, include stock owned in other domestic corporations, which is a duplication cognate with the inclusion in corporate income of dividends received from other domestic corporations. Because of that error, for correction of which no reliable data are available, the first column of figures in Table 3 is given for comparative and corroborative purposes only.

The second column is much more accurate. It contains only the physical assets—inventories, real estate, plant, and equipment. In respect to those assets the income tax returns and capital stock tax returns are fairly comparable, so that an actual compilation year by year is available. The intermediate quarterly figures are interpolated in the same manner as for the first column.

The third column is the statutory net income less taxes. The source of the figures, "Statistics of Income," shows also that nonexempt interest received and interest paid are roughly equal. The figures in the third column may therefore be regarded as true net operating income; hence they can be properly evaluated against tangible investment. The annual totals as taken from "Statistics of Income" are distributed among the quarters on the basis of Barger's data on quarterly earnings.

The figures in the fourth and last column are obviously obtained by dividing those in the third column by those in the second for the same quarter. One could

[4] The figures on reinvested earnings are given in *Invisible Barrier*, p. 83, and the sources are therein noted. Figures for new capital issues are also given there, and the stock portions thereof were determined by reference to the original sources there cited. See also *Statistical Abstract of the United States*, 313 (1930).
[5] Source: *Review of Economic Statistics*, Vol. 14, 199.

TABLE 3

QUARTERLY PROFIT RATE OF UNITED STATES CORPORATIONS
(Amounts in Billions of Dollars)

Year and quarter	Net worth at beginning of quarter	Tangible assets at beginning of quarter	Statutory net income less taxes	Quarterly profit rate (%)
1922—1	101.0	84.3	.53	.63
2	101.5	85.5	.93	1.09
3	102.4	87.4	1.01	1.16
4	103.1	88.8	1.51	1.70
1923—1	103.8	90.3	1.54	1.70
2	105.0	93.2	1.64	1.76
3	105.9	95.5	1.20	1.26
4	106.5	97.0	.99	1.02
1924—1	107.4	99.2	1.39	1.40
2	108.2	101.4	.94	.93
3	109.0	103.6	.90	.87
4	109.6	105.2	1.25	1.19
1925—1	110.4	107.5	1.48	1.38
2	111.7	109.0	1.55	1.42
3	112.9	110.4	1.68	1.52
4	114.0	111.7	1.74	1.56
1926—1	115.3	113.3	1.51	1.33
2	116.4	114.7	1.57	1.37
3	117.5	116.0	1.63	1.41
4	118.4	117.2	1.57	1.34
1927—1	119.3	118.4	1.45	1.22
2	122.8	120.4	1.29	1.07
3	126.1	122.3	1.35	1.10
4	128.9	123.9	1.29	1.04
1928—1	132.4	125.9	1.48	1.18
2	134.6	126.9	1.62	1.28
3	137.4	128.2	1.84	1.42
4	139.5	129.2	2.10	1.63
1929—1	142.9	130.7	1.79	1.37
2	147.6	132.8	1.95	1.46
3	152.5	134.9	2.08	1.54
4	157.0	136.9	1.73	1.26
1930—1	160.3	138.3	.36	.26

divide the figures in the third column by those in the second column for an earlier quarter—say, a year or more back—in order to allow for a development period in respect to new capital, and thus relate earnings to the capital from which they were expected. As a quick computation will show, however, the relative profit-rate position of the various quarters would be almost precisely the same. The obvious reason is the fact that during the particular years involved the rate of growth of total capital invested was fairly constant.

The profit-rate figures shown tell a very clear story. First, during the eight years 1922–29, inclusive, the earnings rate was quite stable—indeed, remarkably stable for such a long period and in an unsupported and uncontrolled economy. Second, during five quarters, three of which were in succession, the earnings rate was higher than during any quarter in the historic boom year of 1929. Third, the rise in profit rate from 1927 reached its peak in the last quarter of 1928. Fourth, the profit-rate peaks were followed, as well as preceded, by a high rate of investment; and the new capital issues of 1927–29 reached their peak in the second quarter of 1929 and were still high in

the third quarter of that year. Decreases in the rate of investment, it can only be concluded, do not precede decreases in the profit rate. When decreases in the rate of investment do develop, it is only after the profit rate has fallen, or a rise in the profit rate has failed to keep going or to hold.

Thus my theory is consistent with observed economic behavior. Increases in the rate of investment contribute to increases in the profit rate—up to a certain limit. After that limit is reached a high investment rate will continue in expectation of the same high, or still higher, profits. But it is doomed to disappointment. An excess of investment is created, and a compensating decline must follow.

TABLE 4

QUARTERLY PROFIT RATE OF UNITED STATES CORPORATIONS
(Amounts in Billions of Dollars Adjusted to a
1929 Price Basis)

Year and quarter	Tangible assets at beginning of quarter	Statutory net income less taxes	Quarterly profit rate (%)
1922—1	93.3	.546	.58
2	94.5	.930	.98
3	96.4	.97	1.00
4	97.8	1.43	1.46
1923—1	99.4	1.42	1.43
2	102.0	1.53	1.50
3	104.1	1.16	1.11
4	105.5	.96	.91
1924—1	107.5	1.33	1.24
2	109.6	.93	.85
3	111.7	.89	.80
4	113.4	1.195	1.05
1925—1	115.6	1.359	1.18
2	117.1	1.445	1.23
3	118.5	1.54	1.30
4	119.8	1.596	1.33
1926—1	121.4	1.41	1.16
2	122.8	1.49	1.22
3	124.1	1.56	1.26
4	125.2	1.52	1.21
1927—1	126.4	1.44	1.14
2	128.5	1.31	1.02
3	130.4	1.35	1.03
4	132.0	1.27	.96
1928—1	134.1	1.47	1.10
2	135.1	1.58	1.17
3	136.4	1.77	1.30
4	137.4	2.06	1.50
1929—1	139.0	1.78	1.28
2	141.1	1.95	1.38
3	143.2	2.06	1.44
4	145.1	1.75	1.20

As to economic conditions subsequent to the Great Depression, very little information can be derived from them. Since 1933 the economy has been an increasingly supported economy. From such an economy few principles can be drawn that are valid for an economy which must stand upon its own feet. The question is, what will happen when the supports are gone?

Finally, Mr. Price objects to my suggestion that the economic cycle can be described sinusoidally. In the

first place, as I pointed out in *Invisible Barrier* (p. 158), there are secondary factors, such as the variations in crop conditions and technological advance, which must be added to the primary curve of the investment and profit cycle. In the second place, in the sentence quoted by Mr. Price from Burns and Mitchell, those authors must, especially in view of their own chart, have meant by the sine curve the simple $y = a \sin x$, whereas in my paper in SCIENCE it is obvious, from my equations and the sentence following them, that I was not using the term sinusoidal in the same simple sense, but rather in the sense of a curve oscillating in the manner of a sine curve.

I disregard Mr. Price's reference to Marx. There is no kinship whatever between my theory and the surplus-value theory of Marx. Not that I would yield if there were. It is the province and duty of science to search for truth, and truth cannot be hemmed in by label or dogma. When that time comes science is doomed, and in whatever land.

Addendum: I have recomputed, in terms of a standard dollar, the schedule of figures in Table 3. For this purpose I used the 1929 dollar, but I am not contending that the standard dollar is a necessary refinement for this purpose. I am only presenting the figures (Table 4) for anyone who might so believe, in order to show that the results are substantially the same on that basis.

In arriving at these figures, the net income for each quarter was adjusted to the 1929 dollar on the basis of the wholesale price index. The increase in corporate investment for each quarter was adjusted to the 1929 dollar on the basis of the index used by Kuznets for gross capital formation in *Commodity Flow and Capital Formation* (Vol. 1, Table VIII-2).

The figure for corporate investment at the beginning of 1922, exclusive of inventories, was adjusted to the 1929 dollar on the basis of a composite index, for years prior to 1922, made up of average hourly earnings in the building trades with a weight of $\frac{1}{4}$; building materials prices with a weight of $\frac{1}{4}$; and the prices of metals and metal products with a weight of $\frac{1}{2}$. The amount distributed to each year preceding 1922 is a percentage of the total increase in tangible fixed assets of corporations for the years 1922–29, inclusive, indicated by data for new manufacturing capital expenditures for plant and equipment. Such data go back only to 1915. The amount not accounted for in the years 1915–21 was treated as derived from the period 1905–14.

The inventory segment of total corporate investment as of the beginning of 1922 was, at current prices, already substantially on a 1929 price basis. The method of adjusting for each quarter only the increase in total tangible investment for that quarter is also substantially accurate in respect to the inventory segment because of the stability of the price level for the period 1922–29. No greater accuracy could be achieved because it would be impossible to state with the necessary precision the years from which each inventory total was derived, the portion priced at cost, the portion priced at market, etc.

It is clear that the conclusions derived from the figures prepared on a current-price basis still follow when the figures are adjusted to a standard dollar.

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Shipment of Animal Disease Organisms and Vectors

THE accompanying statement is self-explanatory. We have found, in cases of illegal movement of these materials, the scientific personnel involved were not acquainted with the requirements of law.

Since we are trying to reach scientific personnel with this information, we hope you will find space to include it in your journal.

HUGH C. MCPHEE

Bureau of Animal Industry, USDA
Washington, D. C.

NOTICE TO LABORATORIES, RESEARCH INSTITUTIONS, AND INDIVIDUALS STUDYING ANIMAL DISEASES

Permit Required to Import or Transport Interstate Restricted Animal Disease Organisms and Vectors

In recent months several instances of illegal movement of animal disease organisms and vectors in interstate commerce have come to the attention of the U. S. Department of Agriculture. Conditions under which restricted organisms and vectors can be moved under permit are explained in the Department's Bureau of Animal Industry Order 381, Part 122, entitled "Rules and Regulations Relating to Viruses, Serums, Toxins, and Analogous Products, and to Certain Organisms and Vectors."

Because of the inherent danger of such movements and the increasing need for taking every precaution against the spread of infectious animal diseases, all laboratories, research institutions, and others dealing with animal disease organisms and vectors are requested to comply with this order. Movements are allowed under permit only when such shipments serve the public interest and after ample safeguards are provided to protect against the further dissemination of such agents.

The Act of Congress approved February 2, 1903 (32 Stat. 792; 21 U.S.C. 111) confers upon the Secretary of Agriculture authority to make such regulations and take such measures as he may deem proper to prevent the introduction or dissemination of the contagion of any contagious, infectious, or communicable disease of animals from a foreign country into the United States or from one State or Territory of the United States or the District of Columbia to another . . . whenever in his judgment such action is advisable in order to guard against the introduction or spread of such contagion.

Under that authority, Part 122 of BAI Order 381, "Rules and Regulations Relating to Viruses, Serums, Toxins, and Analogous Products, and to Certain Organisms and Vectors," provides that no organisms or vectors shall be imported into the United States or transported from one State or Territory or the District of Columbia to another State or Territory without a permit issued by the Secretary and in compliance with the terms thereof.