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The Case for Cycles

by Edward R Dewey

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I am indebted to Professor Richard P. Feynman, theoretical physicist of the California Institute of Technology at Pasadena, for the basic structure of the article. Professor Feynman once said to me, "In regard to cycles, the proper scientific assumption to start with is that they are chance. If they cannot reasonably be chance, the next assumption should be that they are caused within the phenomenon or the system of which the phenomenon is an interacting part. Only if the cycles can not be the result of chance or endogenous causes should we undertake to postulate external or exogenous causes." This formula of Professor Feynman's has constituted the basic philosophy of the Foundation from that day to this. It is the framework around which the following paper has been built.

One element of the case for cycles is the great number of examples that exist to illustrate each of the points that can be made. For example, the fact that all known cycles of the same length turn at about the same calendar time is convincing evidence of interrelatedness. But if we can produce 15 or 20 additional examples of cycles of other lengths, each of which behaves similarly, we can be just that much more sure that we are dealing with reality. Unfortunately, the space limitations of "The Case for Cycles" were such that, in the main, only one example of each sort of behavior could be given.

THE CASE FOR CYCLES

By EDWARD R. DEWEY

There is considerable evidence, as we shall see in the pages that follow, that there are natural environmental forces that alternately stimulate and depress mankind in the mass. These same forces may also affect plant and animal life, weather, and even such normally unchanging things as chemical reactions.

In the first part of this paper we shall discuss the evidence that these forces exist, and that they do have the effects attributed to them. In the second part of the paper, to appear in another issue, we shall discuss how such forces might operate; how they might affect living tissue.

The argument for the existence of these forces runs something like this: Almost everything fluctuates. Many things fluctuate in cycles or waves. Many of these waves are spaced very regularly and have other characteristics that indicate that the spacing cannot reasonably be chance. Non-chance spacing must, by the meaning of words, have a cause. This cause must be internal (dynamic) or interacting (feedback or predator-prey) or external. In any event it must be a force of some sort. In many instances this force cannot reasonably be internal or interacting. Therefore it presumably is external.

In the first instance we do not need to know what this force or cause is -it is enough to know that it must be something. We then proceed from there to find it.

Let us admit straightaway, however, that in spite of the evidence, the case for the existence of such forces has not been proved. We do not know that forces of this sort surround us. If they exist, no one knows what they are - although there are some guesses. No one has ever seen them-they are as invisible as radio waves. Few people have even imagined them. We merely assume them, working backward from observed behavior.

In a moment I wish to examine with you the implications of these discoveries, but before I do, you should have in mind more definitely than you may have, a concept or model of what I am talking about. Radios and radio waves provide a good analogy.

We are all familiar with radios and know in a general way how they operate. Each radio sending station emits waves of a different number of cycles per second. The radio receivers in our houses respond to one or another of these vibrations, according to where we set our tuning dial.

Now imagine that a man from Mars is in my house for a visit. He is a good physicist, but he knows nothing of radio sending stations. He studies my radio. From this study he determines that, when he sets the dial a certain way, the radio vibrates 79.4 thousand times a second; and that when my second radio is set to vibrate this way also, it plays the same tune. With these facts before him it does not take him very long to postulate that both rooms are filled with invisible vibrations of some sort to which both radios respond, and that somewhere there is something that generates these vibrations. Further, as the same thing happens when he sets the dials at 104.2, he deduces that there is a second generating force - and so on for each setting.

Up to this point the existence of these waves or these sending stations is purely presumptive. He deduces them by logical reasoning.

Suppose our man from Mars now comes across statistics or studies which show that every ten years or so rabbits in Canada are more abundant, thus creating a rhythmic cycle of great regularity; the population increasing for 4 or 5 years and then decreasing for an equal span of time. He also discovers that rainfall in London and rainfall in India fluctuate in cycles of the same length. So does the abundance of ozone at Paris, the number of caterpillars in New Jersey, the abundance of salmon on both sides of the Atlantic, as well as many other things. What's more, he finds that all things having cycles of this same length tend to crest at the same time.

He also reads that other things act as if they respond to cyclic forces of other time intervals and that always, cycles of the same length tend to synchronize.

"Why! he says, "It's just like that radio thing that I looked at first, except that these phenomena are the receiving sets instead of those little black boxes; and the environmental forces that I deduce are thousands and thousands of times longer. These cycles are measured in years instead of fractions of a second.

"Now,'' he adds, "I'll ask my host to explain all this to me. He can tell me, I am sure, what makes the boxes play the same tunes when set at the same frequency, what makes dozens and dozens of phenomena fluctuate together as if they were subject to the same environmental forces."

Our friend from Mars overrates me. I can explain a little about radio waves and sending stations, but as for the longer cycles, I am lost. All I can do is to share his belief that there must be something that causes them.

Now I am going to ask you to make an effort of credulity and admit-just for the sake of getting on with the story - that these behaviors are so, and that they are the result of some external, invisible, and as yet unknown forces. Later I shall present some of the evidence to support this idea, but for now I wish you merely to consider the implications and corollaries if this thesis proves to be correct.

The first implication is that law, regularity, order, and pattern exist in vast areas hitherto thought to be patternless. A discovery of this sort is akin to the discovery by the ancients that the planets (so called from the Greek word planet, meaning wanderer) did indeed have regular and predictable movements. It is akin to the discovery that the fluctuating levels of the sea (the tides) are regular and hence predictable. It is akin to the discovery of germs, radiation, X-rays, or atoms. It is akin to the discovery that the atomic weights of the elements can be arranged into a periodic table. In fact, it is similar to any of the great discoveries since the dawn of civilization that have driven caprice, disorder, and chaos back toward limbo. I can think of nothing that will extend the area of order into more different areas, more different disciplines, more different phenomena than cycle study - if these postulated forces really exist.

The second implication of cycle study is the enormous increase in the area of predictability. It is the business of science to predict. Thus, two atoms of hydrogen arid one atom of oxygen (H20) under certain conditions will always combine to produce one molecule of water. Insofar as cycles are non-chance phenomena and continue after discovery, we have notably and importantly increased this particular function of science. A way has been opened up to mankind not only to forecast, but thus to circumvent many aspects of what hitherto has seemed the capriciousness of fate.

Third, insofar as cycles are meaningful, all science that has been developed in the absence of cycle knowledge is inadequate and partial. Thus, if cyclic forces are real, any theory of economics, or sociology, or history, or medicine, or climatology that ignores nonchance rhythms is manifestly incomplete, as medicine was before the discovery of germs.

Fourth, if these cyclic forces are real, there is a much greater degree of interrelationship within nature than was previously realized, since the same cycles appear in many different natural and social sciences. The implications are one of wholeness instead of the emphasis we so often see upon smaller and smaller sections of knowledge.

Fifth, if these forces exist, man is further deflated. When a knowledge of cycles becomes widespread, it will create a jolt to man's ego similar to that created by the knowledge that many of his actions are dictated by his subconscious; that the earth is not the center of the Universe; that even our Galaxy is but a speck of dust. To a much greater extent than formerly realized, man has been a cork on the tides of destiny. However, knowledge of these forces-when we know that they really exist-will enable man to foil them. Sufficient knowledge always has this effect.

Sixth, all in all, the Universe is shown to be an even more marvelous place than has hitherto been realized.

These are broad claims indeed, even if it is appreciated that they are corollaries and implications only if these postulated forces exist.

The rest of this paper will be devoted to examining such evidence as we now have in regard to our thesis. In reading it, remember that it would be possible to add many other instances to each example given. In some cases this expansion could be a hundredfold. Keeping this fact in mind, I am hopeful that your conclusion will be that a good deal of evidence for our thesis does exist and that the corollaries and implications are so important that an extensive and intensive effort should be made to confirm (or deny) it.

THE PREVALENCE OF RHYTHMIC BEHAVIOR

More than 500 different phenomena in 36 different areas of knowledge have been found to fluctuate in rhythmic cycles-that is, in oscillations that recur at reasonably regular time intervals. In physics, cycles occur in electromagnetic vibrations, such as light waves, radio waves, X-rays, and in sound waves; in astronomy, cycles are created by the motions and vibrations of various heavenly bodies; in geology, repetitive patterns are found in earthquakes, volcanic eruptions, sedimentary rock deposits, and the advance and recession of glaciers; in biology, rhythmic fluctuations occur in the abundance of various species of animal life and in the functioning of the animals' various physiological processes; and in economics, nonchance rhythmic patterns can be found in prices, production and other aspects of man's material activities. Table 1 lists some of the various phenomena in which rhythmic cycles have been found.

Table 1: DATA HAVING CYCLES

NATURAL SCIENCE

ASTRONOMY AND ASTROPHYSICS
Auroras, comets, meteor showers
Planets, satellites, asteroids
Rotation of galaxies
Sunspots and other solar phenomena
Variable stars

BIOLOGY

Bacteriology
Abundance and activity of bacteria in human beings

Botany
Abundance of crops, plants, seeds, and algae
Assimilation and photosynthesis
Concentration of growth substances
Electrical conductivity of sap
Electrical excitability of mimosa
Electrical potential of trees
Fiber and individual organ growth
Nectar production and sugar content
Photoperiodicity
Thickness of tree rings

Entomology
Abundance and activity of insects
Feeding, hatching, and migration
Pigment changes of certain insects

Herpetology
Abundance of snakes and amphibians
Activity of lizards and salamanders
Pigment changes in salamanders

Ichthyology and Limnology
Abundance of algae, plankton, and fish
Egg cycle of various fish
Migrations

Invertebrate Zoology
Abundance of various invertebrates
Body temperature and metabolic rate
Contraction waves in worms
Germ cell maturation
Light production and photic responses
Migration of various invertebrates
Surface color and pigment changes

Mammalogy
Abundance and activity of various mammals
Fur production
Physical cycles and activity-rest periods
Variations in milk production

Ornithology
Abundance of various birds
Metabolic activity
Migration
Wing beats of various birds

CLIMATOLOGY

Air movements and wind direction
Barometric pressure and temperature
Glacial movements
Ozone content of the atmosphere
Precipitation, including abnormalities
Storm tracts

GEOLOGY

Earthquakes, geysers, volcanic eruptions
Encrustations of archaeological artifacts
Geologic epochs and periods
Sedimentary deposits, varves, seiches
Soil erosion
Thickness of rock strata

GEOPHYSICS (also see Climatology)

Radio propagation quality
Terrestrial magnetism

HYDROLOGY AND HYDROGRAPHY

Lake, river, and sea levels
Ocean currents, temperature, and waves
River flow and run-off Tides

MEDICINE

Abundance of disease organisms and parasitic worms
Births and mortalities
Blood pressure and blood-sugar content
Body temperature and metabolism
Electrical skin resistance
Emotions and mental activity
Endocrine and glandular secretions
Epidemics and pandemics
Fevers and after-shock
Incidence of diseases and disorders
Muscular, nervous, and sexual activity
Plasma chemistry variations
Psychiatric abnormalities
Respiration and visceral activities
Teeth sensitivity
Veterinary diseases

PHYSICS

Activity of electrons and molecular vibrations
Electromagnetic waves and flux
Radio and sound waves

SOCIAL SCIENCE

ECONOMICS

Advertising efficiency
Agricultural production
Building and real estate activity
Commodity prices
Financial data
General business activity
Imports, exports, trade activity
Production, consumption, sales
Purchasing power
Transportation
Wage earner activity

SOCIOLOGY

Civil and international war battles
Creativity and inventiveness
Crime
Cultures and civilizations
Fashion
Human ability, excitability, output
Insanity
Intellectual interest
Liberalism versus conservatism
Marriages and births
Military-political activity
Periods of emotional excitement
Population
Religious and scientific activity
Strikes and unemployment

Life abounds with rhythmic cycles. The cause of some of these cycles is known (photoperiodicity for example). The cause of other rhythmic cycles is mere chance. But some rhythmic cycles of unknown cause can be shown to be non-chance. It is these cycles that arouse our curiosity and our interest.

Let us turn now to the evidence that leads us to believe that some of these rhythmic cycles of unknown cause are not of chance origin.

EVIDENCE OF SIGNIFICANCE

Individual rhythms are often significant in their own right because the pattern - the reasonably regular recurrence of ups and downs - is so ordered that it is not likely to be the result of chance.

Obviously, some rhythmic patterns, such as those that can sometimes be found in a table of random numbers or in a chart of such numbers, are of chance origin. It is equally obvious that other rhythmic patterns, such as the alternation of day and night, winter and summer, high tide and low tide, are not.

If we do not know the cause, we can often judge from internal evidence alone the probability of the behavior being chance or non-chance. Statistical techniques have been and are being devised to answer just such questions.

There are, moreover, a number of additional criteria by which significance of pattern in the behavior of any one phenomenon, taken by itself, can be determined. In brief, these are: the extent to which the pattern is dominant, regular and repetitive, maintains a uniform period, reestablishes itself after distortion, continues over long periods of time (that is, through changed environmental conditions), persists after discovery, and evidences non-chance characteristics such as symmetry.

Let us consider these criteria one by one and, by way of illustration, give one example of behavior that fulfills the test.

CYCLE DOMINANCE

Cyclic dominance is the degree to which the ups and downs of a time series are the result of the cycle in contrast to the variations that are caused by other factors. A series is a collection of data arranged in some order. A time series is an arrangement of data that measures the successive changes in phenomena over a period of time. Average annual temperatures at New Haven from 1781 to 1966 constitute a time series, as do successive stock price quotations.
Dominance can be measured in respect to the actual data or in respect to the data after the removal of trend. Trend is that element in a time series that changes its direction slowly. Trend measures growth (or decay, which is negative growth) in contrast to the fluctuations. Fluctuations, whether rhythmic or random, are the oscillations around the trend and the departures from trend. They are ordinarily measured as percentages of trend.

Figure 1 shows the variations in the offerings of lynx skins in Canada from 1735-36 through 1962-63. The offerings of lynx skins are generally considered to be a very good measure of the abundance of the lynx. The dominance of a rhythmic cycle is evident and is the most important characteristic of this behavior. The period of this cycle is 9.6 years, which is the average or typical interval between crests or troughs.

I have added a 9.6-year zigzag to idealize the timing of the rhythmic cycle. This zigzag is a true periodicity (a fluctuation of perfect regularity) in contrast to the merely rhythmic behavior of the actual figures. No one knows the cause of this cycle or why it is 9.6 years long.
Not all cycles are as dominant as the 9.6-year cycle of lynx abundance. For this reason it is often

necessary to use other criteria in order to decide whether or not rhythmic behavior is to be considered the result of chance. One of these criteria is the regularity of the cycle.

REGULARITY OF TIMING

Obviously, the more the behavior of the phenomenon adheres to some true periodicity or pattern, the less likely it is to be the result of chance. The 9.6-year cycle of lynx abundance charted in Figure 1 is quite amazingly regular, and this fact gives us another reason for thinking that lynx abundance is non-chance behavior. There are many dramatic examples of phenomena with regular patterns of behavior. One of these is the sales of a New England textile plant. A chart of sales from 1931 through 1940, after removal of trend, showed a remarkably regular 3-month cycle. This is illustrated in Figure 2 where the actual monthly sales, as percentages of trend, are shown in comparison with a true 3-month periodicity. No one knows the cause of this cycle, but it cannot reasonably be due to chance.

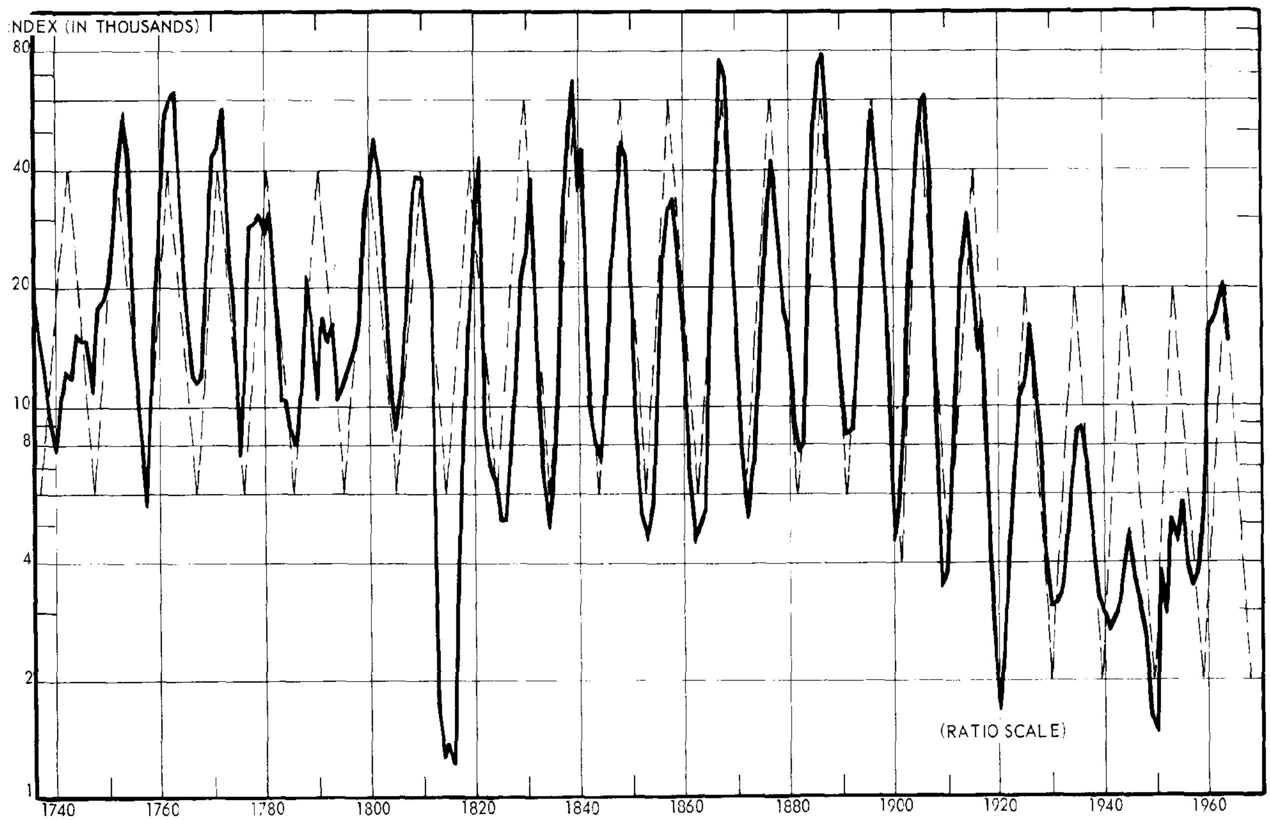


Fig. 1: AN EXAMPLE OF AN ESPECIALLY DOMINANT CYCLE

An index of lynx abundance, Canada, 1735-36 to 1962-63. The period of this cycle - i.e., the average time interval between crests or troughs - is 9.6 years. This timing is indicated by the rigid periodicity diagrammed by the thin broken line.

The dominance of this cycle, coupled with the number of repetitions and their regularity, shows that this cycle cannot reasonably be the result of chance. We may therefore suppose that it is created by dynamic forces within the lynx population, or by a predator-prey relationship, or by some environmental force or forces.

Cycles do not need to be as regular as this one to indicate a non-chance origin. Many repetitions of an irregular cycle are just as convincing to the expert as a few repetitions of a regular cycle. In fact, the cyclic forces are often so weak that they are unable to produce any visible rhythms at all. Under these circumstances their presence must be determined mathematically. When observable regularity is present, however, it is an additional criterion of significance to indicate non-chance behavior.

NUMBER OF REPETITIONS

It is obvious that the greater the number of waves in a cyclic recurrence, the greater the odds that the regularity is not the result of chance. For example, it is much more difficult to find ten successive waves of about the same length in chance figures than to find five. To prove this, toss a coin. See how many tries it takes to get five successive heads/tails in ten throws; then see how many tries it takes to get ten successive heads/tails in twenty throws.

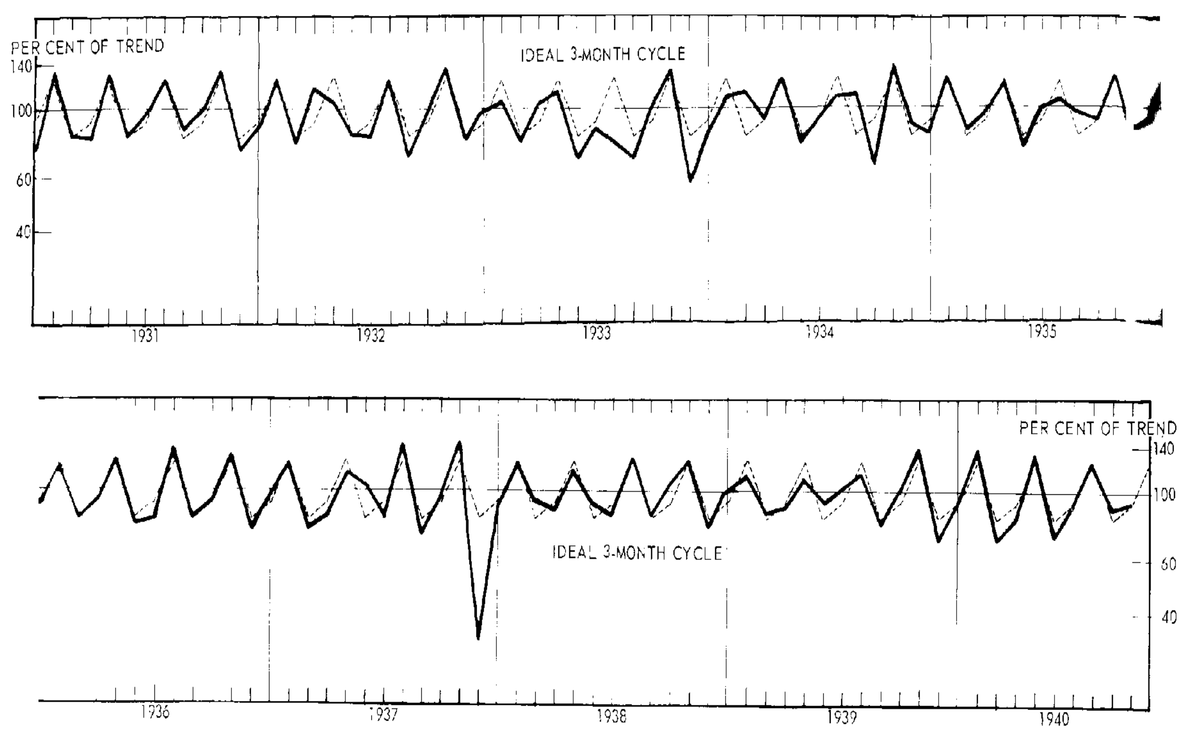


Fig. 2: AN EXAMPLE OF AN ESPECIALLY REGULAR CYCLE

Monthly sales of a large manufacturing company after removal of the short term trend, January, 1931-October, 1940. The period of this cycle is 3 months, as diagrammed by the thin broken lines.

A cycle as regular as this, and as dominant, and as repetitious, cannot reasonably be the result of chance. It must have a cause.

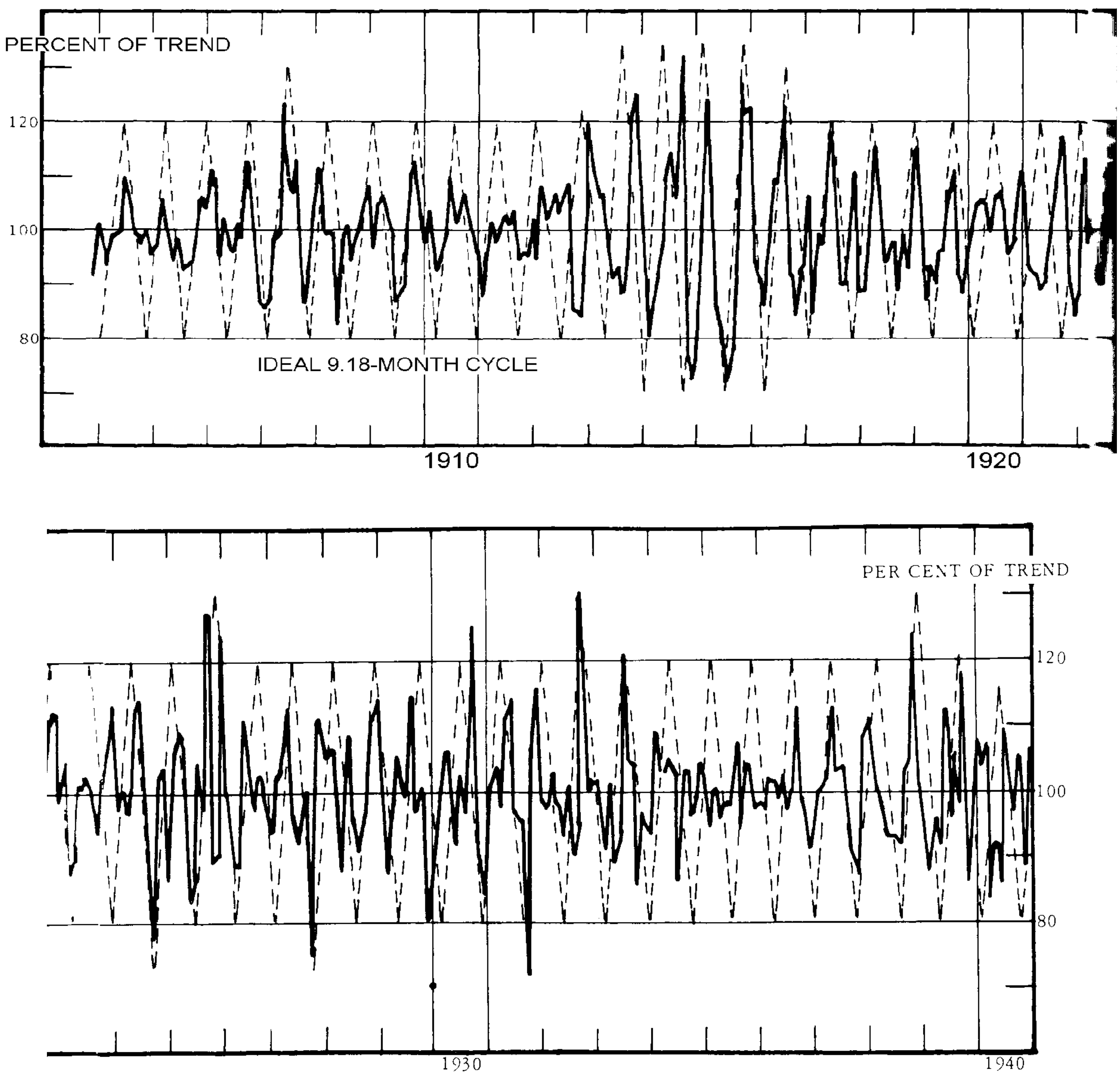


Fig. 3: AN EXAMPLE OF A CYCLE THAT HAS REPEATED MANY TIMES

The chart shows the ton miles of the Canadian Pacific Railway, July, 1903-December, 1940 after removal of trend and seasonal variation.

A 9.18-month rhythmic cycle is clearly evident by inspection. It has been diagrammed by a rigid 9.18-month zigzag. Within the interval shown this cycle repeated 48 times. It cannot reasonably be random behavior.

Figure 3 illustrates repetitions which could hardly be the result of chance. The chart shows monthly ton-miles of the Canadian Pacific Railway from July 1903 through December 1940 after the trend and the 12-month or seasonal cycle have been removed. A rhythmic cycle with a 9.18-month period repeats 48 times! The timing of this cycle is diagrammed by the broken zigzag line. It is inconceivable that waves which repeat as many times as the 9.18-month cycle in Canadian Pacific Railway ton-miles could occur by chance.

There is a difficulty, however, when the number of repetitions is used as a gauge of cycle significance because many series of figures are too short to allow a large number of repetitions. For the most part we have not been recording facts for more than 50 or 100 years. A cycle may have existed in some phenomenon for hundreds of years, but we have no records to show this.

Although both the 9.6-year lynx cycle and the 3-month textile cycle have many repetitions, there are not as many repetitions as in the 9.18-month cycle of Canadian Pacific Railway ton-miles. The repetitions, however, occur often enough, and the patterns in the lynx and textile cycles meet additional criteria, which gives cumulative evidence of non-chance behavior.

CONSTANCY OF PERIOD

If a cycle in a series of figures persists over many repetitions with no change o f period we have additional evidence that the cycle is not of chance origin.

Refer to Figure 4 which shows sinusoidal curves fitted to each fifth of a long varve record. Varves are annual layers deposited on the bottoms of lakes. These layers vary in thickness from year to year. These variations are cyclic. One of the Lake Saki varves cycles, shown here, is about 17.323 years long. The first curve, A, idealizes the average of the first forty-eight 17.323-year sections of the data, 2291 B.C. through 1460 B.C.

Curve B idealizes the same cycle in the next forty-eight 17.323-year sections, and so on. Each cycle is repeated by a broken line. Except for minor variations, due presumably to random distortions, the period holds constant throughout the entire 4,160-year period.

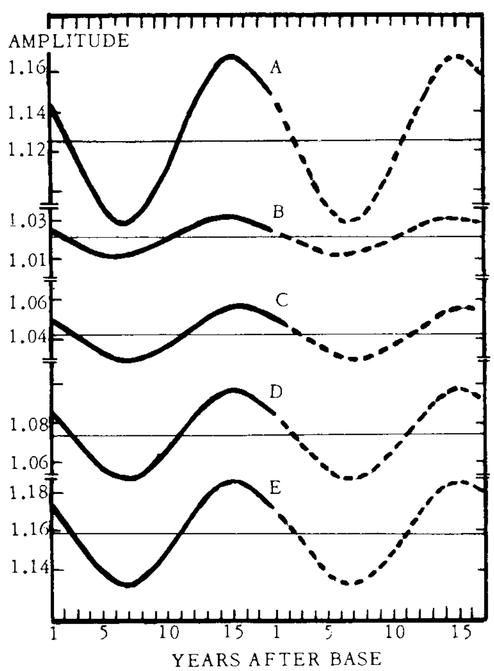


Fig. 4: A CYCLE OF UNCHANGING PERIOD

The chart shows sinusoidal curves fitted to average 17.323-year cycles in Lake Saki varves in each of five 8 32-year sections of the data (48 waves each) from 2291 B.C. through A.D. 1869. Each cycle is repeated in phantom by means of a broken line.

The fact that the waves fall almost exactly under each other shows that there is almost no change in the length of the cycle. What little change there is is presumably the effect of randoms that do not fully offset each other through the averaging process.

This cycle in these figures is so distorted by other cycles and randoms that it cannot be seen easily as a wave-by-wave rhythm. However, when a number of waves are averaged together the randoms offset each other and the cycle appears, largely freed from distortion.

REESTABLISHMENT OF PHASE

Phase is a technical term which refers to a particular state or stage in a recurring cycle of changes. For example, the phases of the moon. When the waves of a rhythm are in step with what they were before, they are said to be "in phase" with previous behavior. When they are not in step they are "out of phase."

If, after a distortion, the cycle in a series of figures reasserts itself in phase-in step-with its previous timing, the cycle is much more likely to be nonchance or significant than if it does not. The fact that rhythmic cycles almost always do this is one of the more convincing arguments for the non-chance nature.

Figure 5 shows the year-to-year rate of change in the monthly production of pig iron from January 1901 through December 1940. The fluctuations are characterized by the broken zigzag line. The cycle is quite dominant, quite regular, and shows 11 and 1/2 repetitions. A majority of the crests fall within three or four months one way or the other of typical timing. The regularity of the crests is indicated by the brackets on the top of the chart, while the equal regularity of the troughs is indicated by the brackets on the bottom.

Follow the behavior wave by wave: first wave, a-B-b; second wave, b-C-c; third wave, c-D-d; fourth wave, d-E-e, and so on. The sixth wave is badly distorted by World War I, but the seventh wave, g-H-h is entirely back to the schedule as determined by the pre-war behavior. Again, wave h-I-i is somewhat distorted. The trough at j, during the depression, was a year late. Wave k-L-1 is normal, however, and the cycle continues normal up to the beginning of World War II.

In almost all non-chance rhythmic cycles, after a distortion, the waves return to pre-distortion timing.

PERSISTENCE THROUGH CHANGED CONDITIONS

When a rhythmic cycle persists in spite of changed environmental conditions we have additional evidence that it is of a non-chance nature. For an example of this situation we have chosen a series of figures from the field of economics, because it is in this field that the greatest changes have taken place over the years.

Figure 6 shows the prices of wrought iron in England from 1288 to 1908, with trend removed, together with a diagram of its 16 2/3-year cycle. Note that this cycle has remained a constant characteristic of these figures from before the Industrial Revolution, through the Industrial Revolution, and up into the era of modern technology.

In seeking cycles in a series of figures one needs to know what to look for. Cycles are normally distorted by trend, by randoms, and by other cycles. Crests and troughs almost never come exactly on time. Extra crests and troughs often appear. All this usually makes the cycle hard to see. Thus, one looks for areas of strength followed by areas of weakness.

Knowing all this, in the example given A, B, C, D, and E are excellent crests. One is not misled by the false peaks between E and F, G and H, or by the three crests between H and J and between J and L (where, in both cases, the 16 2/3-year pattern calls for two peaks). The pattern reasserts itself with L, M, N, 0,-Q, R, S, and T. (P is somewhat distorted. So is U; but V is back on the track.) The cycle is then practically missing to AA, but after AA we have BB, CC, and DD. Extra crests exist between EE and FF, HH and II, and after KK, but GG, II, JJ, and KK are all good crests, reasonably on time.

For the sake of simplicity I have spoken only of crests. Troughs must be considered too. In fact, in actual analysis every point on the curve is considered.

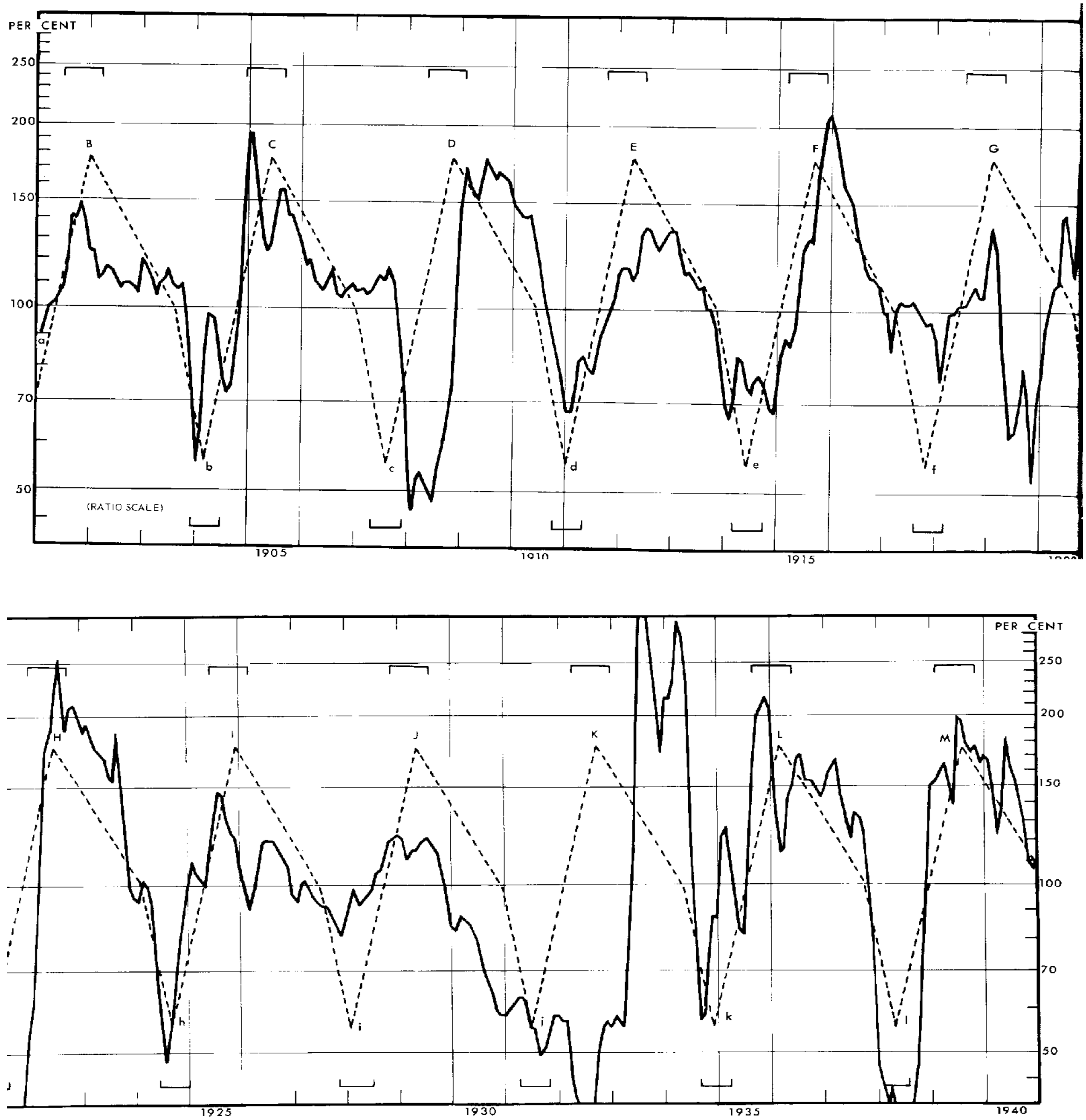


Fig. 5: AN EXAMPLE OF A CYCLE THAT REASSERTS ITSELF AFTER DISTORTION

The chart shows the yearly rate-of-change in pig iron production, January 1901 - December 1940, together with a diagram of a perfectly regular 41-month cycle. Note that after the distortion of 1919 and 1920 following World War I, the previous pattern reasserts itself. Similarly, after the distortions of 1932 and 1933. Note that, in spite of all distortions, randoms, and other cycles also present in these figures, a majority of crests and troughs fall within three or four months one way or the other of perfect timing, as shown by the small brackets.

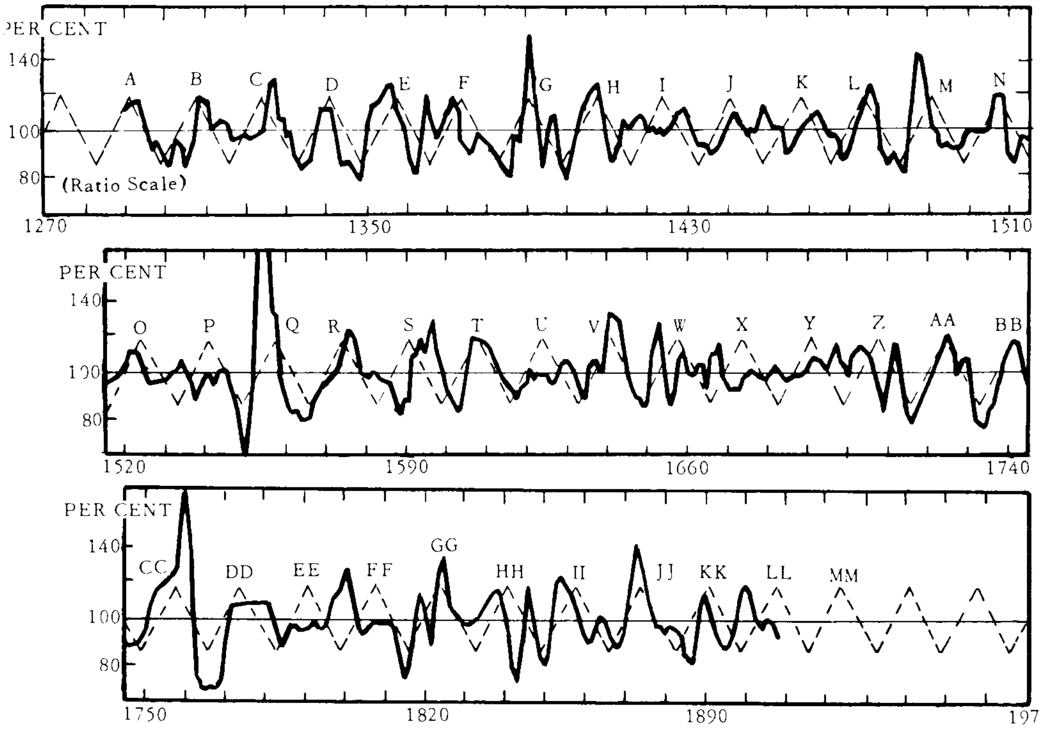


Fig. 6: AN EXAMPLE OF A CYCLE THAT HAS CONTINUED UNCHANGED THROUGH CHANGED ENVIRONMENTAL CONDITIONS

The chart shows wrought iron prices in England, 1288-1908 with trend removed, together with a diagram of a perfectly regular 16 2/3-year cycle.

There are many irregularities, but on the whole, areas of strength are followed by areas of weakness at about 16 2/3-year intervals.

Note that after distortions the previous pattern reasserts itself.

PERSISTENCE AFTER DISCOVERY

If the cycle keeps on coming true after discovery we have powerful evidence that the pattern is not the result of chance.

The reason for this is easy to see. When we examine a series of figures for the possible presence of rhythmic cycles we are free to select any cycle length that fits the fluctuation. With 100 years of figures, let us say, we are free to choose any cycle length from two years (50 repetitions) to 50 years (two repetitions). Suppose this range gives us 50 choices. Suppose we find a 4-year cycle. Suppose, through passage of time or otherwise, we obtain a continuation of the series of figures. We wish to see if our 4-year cycle continues to come true. But on the continuation of the figures we no longer have 50 choices. We are limited to one choice-the 4-year one. If the figures are random it will be 50 times as hard to find one particular cycle determined in advance as it was when we had our choice of any one of 50 cycles. Therefore, if we do find the predetermined cycle in the continuation of the series, we are justified in saying that the probability of randomness has decreased, perhaps fifty-fold.

Cycle study is so new that most cycles have not had much chance to continue after discovery. This fact makes the criterion of coming true after discovery hard to apply. The difficulty could be

TABLE 2: PROFIT AND LOSS FROM IMAGINARY PURCHASE AND SALE, AND SHORT SALE, ACCORDING TO BENNER'S "CAST IRON RULE," 1872 TO 1939

Date	Buy at	Sell at	Short at	Cover at	Gain or Loss Actual		Per Cent	
					Long	Short	Long	Short
1872			$48.94					
1877	$18.92			$18.92		$30.02		61.3
1881		$25.17	25.17		$ 6.25		33.0	
1888	18.88			18.88		6.29		25.0
1891		17.52	17.52		-1.36		-7.2	
1897	12.10			12.10		5.42		30.9
1899		19.30	19.30		7.26		60.0	
1904	15.57			15.57		3.79		19.6
1908		17.57	17.57		2.00		12.8	
1915	14.01			14.01		3.56		20.3
1918		33.25	33.25		19.24		137.3	
1924	22.10			22.10		11.15		33.5
1926		21.64	21.64		-.46		-2.1	
1931	17.35			17.35		4.29		19.8
1935		18.68			1.33		7.7	
				TotaI per cent gains, long			250.8	
				Total per cent gains, short				210.4
				Total per cent gains				461.2
				Total per cent losses, long			9.3	
				Total per cent losses, short				0
				Total per cent losses				9.3
				Gain - loss ratio				50 to 1

overcome if all cycle determinations were made on a part of the data and the discovered cycle or cycles projected upon the remaining part. However, this procedure involves double work because, for the most accurate determination, one wants to use every scrap of data available; using part of the data to start with means doing the work all over again. Determining the length of the cycle from part of the data and then comparing the cycle so determined with the rest of the data is therefore not usually done.

For our example of a cycle coming true after discovery, let us go back to one of the earliest cycle determinations -the 9-year cycle in pig iron prices which was discovered by Samuel Benner in 1874. In studying pig iron price behavior in the data available to him at that time, Benner noticed that peaks in these figures came at 8-, 9-, and 10-year intervals and repeat (an average 9-year cycle), and that troughs came at 7-, 11-, and 9-year intervals and repeat. He projected this pattern from 1872 into the future. This gave him the years in which to buy, the years in which to sell. If you had used these dates for trading, your percentage gains between 1872 and 1939 would have been 50 times your losses! See Table 2.

The true length of this pig iron price cycle is 9.2 years, but Benner did not know how to handle cycles of fractional year periods. Consequently his forecast got off the track by one year every five waves. By 1939 his projection was no longer usable.

A variation of this criterion of seeing whether a cycle continues after discovery occurs when one presupposes a particular cycle length, looks for it, and finds it. The 17.323-year cycle in Lake Saki varves, used to illustrate the previous section called "Constancy of Period" was determined this way. Enough is known about cycle behavior so that it was possible to say, without any preliminary

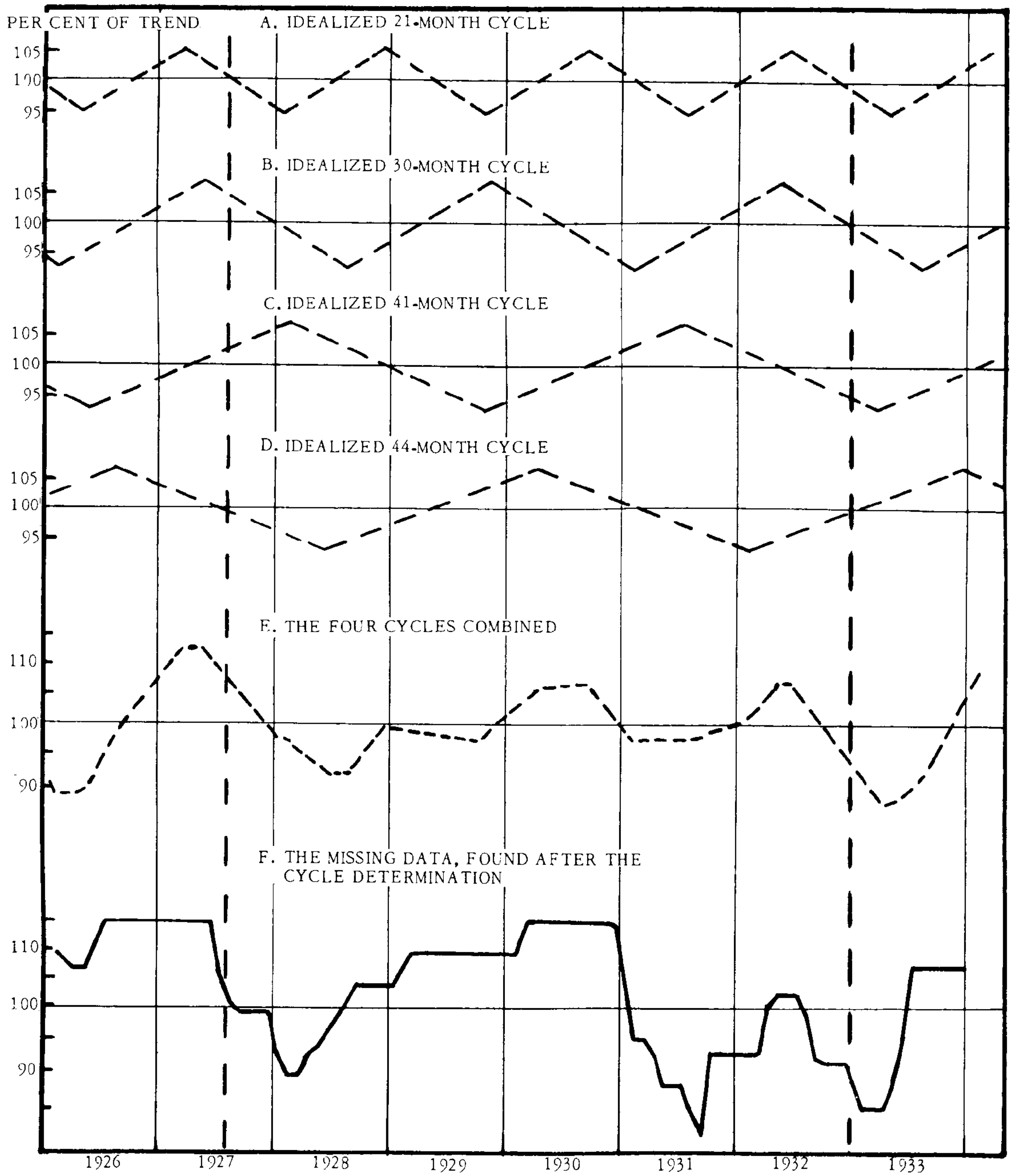


Fig. 7: AN EXAMPLE OF SEVERAL CYCLES PRESENT CONCURRENTLY IN THE SAME PHENOMENON

Curves A, B, C, and D diagram the 21-, 30-, 41-, and 44-month cycles in the prices of malleable iron pipe fittings, January, 1926 through December, 1933. Curve E shows their synthesis. Curve F shows actual prices for the same period, as percentages of trend.

It is interesting to note that the cycles were determined from data March 1923 to July 1927 and from January 1933 through 1948. Data August 1927 through December 1932 were unavailable when the analysis was made. Yet, when later obtained, the prices for this 5 1/2-year period were quite realistically represented by the synthesis of the four cycles determined without any knowledge of them.

reconnaissance, "There ought to be a cycle about 17 1/3 years long in these figures. Let us see if it is there." It was.

To find a cycle of considerable strength, constant period (average cycle length, measured in time) and predetermined length, over a 4,000-year span of time in random numbers would be, for all practical purposes, impossible. Ergo, the figures are not random.

Later we shall see how it was possible to suspect, without even looking, that there was probably a cycle of this length in this series of figures.

COMPLEX CYCLES

Many phenomena act as if they were influenced simultaneously by two or more cyclic forces. For example, the prices of malleable iron pipe fittings from January of 1923 through December of 1948 are characterized by four cycles of 21, 30, 41, and 44 months.

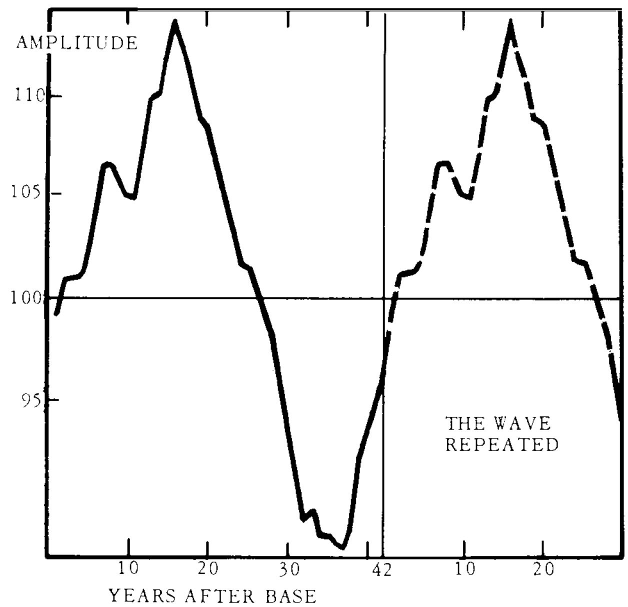


Fig. 8: A TYPICAL WAVE SHAPE

The chart shows the average 42-year cycle in cotton prices.

It is an interesting point that these cycles were determined by data from March 1923 to July 1927 and January 1933 to December 1948. Data were missing for the five and one-half-year period from August 1927 through December 1932. These five and one-half years of data were later discovered, and found to fit the previously determined pattern dramatically. Figure 7 shows these prices for this span of time together with the synthesis of the four cycles as determined from the two ends of the curve before the 1927-1932 prices were known.

It is not impossible to find more than one rhythmic cycle in a series of random numbers. However, when the combination of cycles as determined from part of a series of figures conforms to the behavior of another part of the series not used in the cycle determination, the probability of such correspondence arising by chance is very small indeed.

WAVE SHAPE

Cycles in random numbers, when you can find them, are likely to be of any shape. Many of the cycles we find in figures of social and natural science phenomena, however, are symmetrical. Behavior of this sort would be extraordinarily difficult to find in chance fluctuations. Wave shape thus gives us a ninth criterion of significance.

Although the shape of the various waves can sometimes be seen by inspection of a chart of the data, a more accurate representation is obtained by averaging together a number of waves. This is the process used by the meteorologists to find the typical shape of the average annual temperature or rainfall cycles. The same principle can be used to find the shape of a 9.6year cycle, a 9.18-month cycle, or a cycle of any other length.

Figure 8 shows the average shape of the 42-year cycle in cotton prices.

Not all non-chance cycles are symmetrical. As we have seen, the 41-month cycle in pig iron production rate-of-change goes up fast, goes down slowly, as do the variations in sunspots. So do the light curves of variable stars (Figure 9). A symmetrical shape is not a necessary attribute of significance. It is merely an added criterion which, when present, can be used to help to distinguish between chance and non-chance rhythms.

MATHEMATICAL TESTS

There are various mathematical tests that can be applied to tell how many tries would be necessary with random numbers to get a cycle as good as the one under observation. There are faults that can be found with all of these tests, but this is not the place to discuss them. Notwithstanding their faults, the tests are often useful, at least in a comparative way, to indicate which one of two cycles is the more significant.

Figure 10 charts the 9.2-year cycle in stock prices, U.S.A., from 1834 through

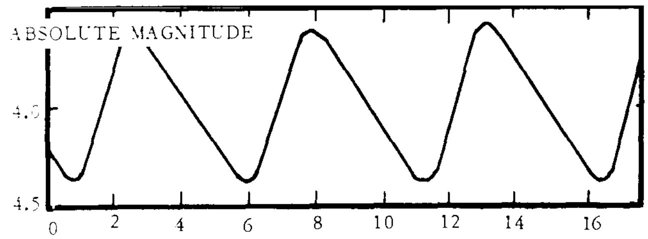


Fig. 9: THE LIGHT-CURVE OF A TYPICAL CEPHEID VARIABLE

Note the rapid rise in briIiance followed, each time, by a more gradual decline.

The curve of the successive waves in the varying briliance of this star is very regular and even. On the other hand, the average curve of the 42-year cycle in cotton prices is not so smooth. Nevertheless, the typical zigzag shape of the cycle in cotton prices is quite apparent. The cotton price average cycle has not been manipulated or smoothed in any way, other than by the average (after trend removal).

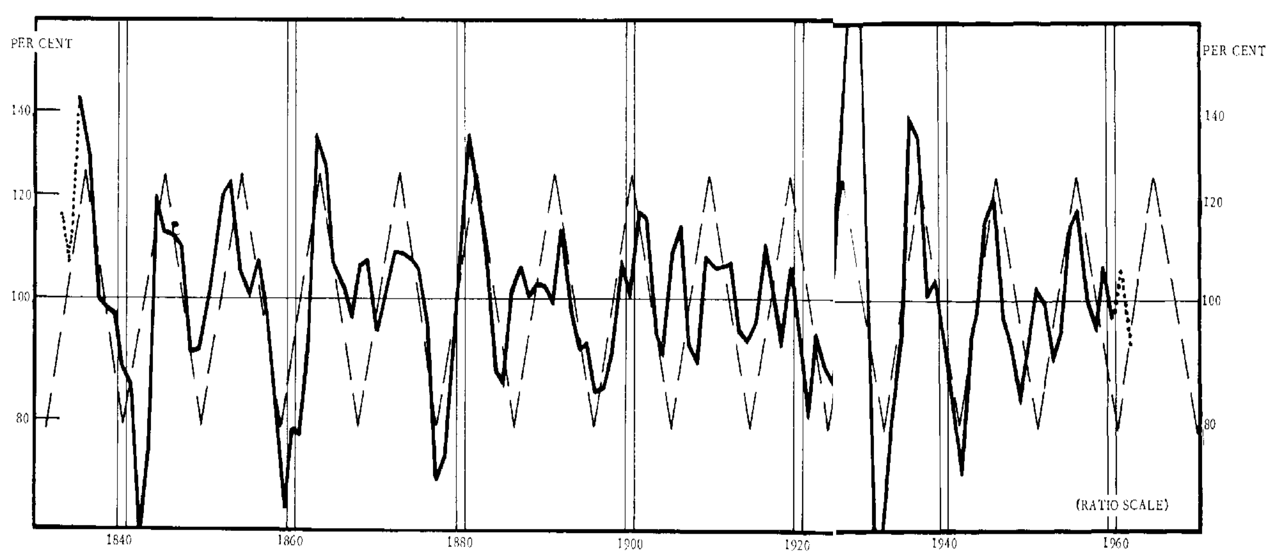


Fig. 10: AN EXAMPLE OF A CYCLE OF HIGH MATHEMATICAL SIGNIFICANCE

The chart shows the 9.2-year cycle in common stock prices, after removal of trend, 1834-1966, together with a rigid 9.2-year periodicity. According to the Bartels test, a cycle of this dominance, this regularity, and this number of repetitions could not be the result of chance more often than once in 5,000 times.

1966, after the removal of trend. According to a test of significance developed by the late Dr. Julius Bartels of the Carnegie Institution of Washington, a cycle as dominant, as regular, and as repetitive as this one could not be found in random numbers more often than once in 5,000 times.

A RESUME

Up to this point we have been discussing the 10 criteria, each of which helps us to decide, for the rhythm in any one series of figures considered by itself whether or not the rhythm is the result of chance. Is the pattern there merely by coincidence -or does the pattern have a cause? We do not need to know what the cause is, but if the pattern is not random there must be one.

The ten criteria that we may use to help throw light on the significance of a cycle in a single series of figures are: 1.) Is the cycle dominant? Does it prevail over randoms and other cycles? 2.) Is it regular? That is, does it repeat time after time with a beat-with rhythm? Is it sufficiently regular? 3.) Has it repeated enough times? The determination of just how many times is "enough" depends of course upon the cycle dominance, the cycle regularity, and other factors. 4.) How constant is its period (average cycle length)? Cycles of random origin do not hold to a fixed period wave after wave, century after century. Significant cycles do. 5.) After distortion, does the cycle reassert itself in step with the timing it had before the distortion? If the cycle does this, it is very hard to believe that the behavior is chance. 6.) Does the cycle persist throughout changed conditions? Does the cycle control, or do circumstances? 7.) Does the cycle keep on coming true after discovery, or when its period is postulated as a result of basic cycle knowledge? 8.) Do two or more cyclic patterns pretty well describe after-unfolded or after discovered data? 9.) Are wave shapes, individually or on the average, of a non-random nature, e.g. smooth, or symmetrical? 10.) Do mathematical tests confirm some or all of the above criteria?

Keep in mind that all we have been discussing so far are some criteria for judging the probability that the cycles in a particular time series are or are not the result of chance. Any one of these criteria, except perhaps dominance and wave shape, can be used by itself, but of course the more criteria that apply to any given behavior, the greater the probability that the behavior- the rhythm, or the cycle present on the average - is not the result of chance. At this point we do not care whether the cycle will keep on coming true, or is any good for forecasting, or is the result of dynamics, feedback, predator-prey, or external forces. The question is merely, "Is the regularity accidental or is there some cause for it?"

It should be clear from even the few illustrations given that there are at least some cycles so dominant, so regular, so repetitious, and so persistent that they cannot reasonably be the result of chance.

If space permitted, it would be easy to supplement these illustrations with scores-even hundreds-of additional examples. The single graphic example given should suffice to demonstrate each criterion. These criteria have dealt with the individual cycle under consideration. That any particular cycle is significant can thus be self-evident, if it meets these criteria.

EXTERNAL

EVIDENCE OF SIGNIFICANCE

Let us now turn to a consideration of additional criteria that become available to us if we engage in what is known as comparative cycle study.

For the most part, comparative cycle study involves studying cycles of the same length (period) in different phenomena. As we shall see, the presence of cycles of the same period, turning at the same time, evidencing the same shape and geographical distribution, provide not only additional evidence of non-randomness, but take us a considerable distance toward the discovery of cause.

Let us now consider the eight additional criteria of significance that can be obtained by studying cycles comparatively. These additional criteria are: 11.) Cycles of the same period are found in many different phenomena. This is a circumstance that would be very hard to reproduce by chance. The suggestion is that the cycles involved may be interrelated or may be the result of a common cause. 12.) All the cycles of the same period so far studied turn at about the same calendar time. This synchrony cannot reasonably exist with random or unrelated cycles. 13.) The implications of correspondences of period and timing are greatly increased when some of the cycles with the same period can be shown to be nonchance in their own right. 14.) Cycles of the same period in different phenomena have been found to have the same shape. Here again, such behavior suggests interrelationship or common cause. 15.) Cycles of the same period, regardless of phenomenon, evidence geographical pattern. They crest later and later as found from the north pole toward the equator. A pattern of this sort could not arise easily by chance. 16.) A further non-chance characteristic of cycles of the same period in different phenomena is that the geographical patterns just referred to are distorted in much the same way that magnetic declination patterns are distorted. 17.) A complete spectrum of alleged cycle periods concentrates at particular points instead of evidencing a reasonably even distribution. If the cycle periods were randoms, they would scatter. 18.) And finally, there appear to be families of cycle lengths. Cycle periods are often related to each other by simple arithmetic ratios.

Let us now examine each of these points in detail.

IDENTITY OF CYCLE PERIODS

It is hard to find cycles in random numbers, but it can be done. Let us take 200 random numbers, rearrange them 100 times, and pick the best cycle we can find in any of these arrangements. Suppose that in one of these 100 arrangements we find a fairly good cycle and that its period is 7.1 terms. Next we can make 100 more arrangements of these (or some other) random numbers and look for the cycles in the second one hundred tries. Let us say we find a fairly good cycle in one of these second 100 tries, and that this second cycle is 14.8 terms long. With a complete assortment of periods to look for it would be amazing if any significant cycle in the second 100 tries turned out to have exactly the same period-7.1 terms-as the cycle that was found in the first 100 tries.

Conversely, if, in two series of real figures, we do find cycles of identical period, it suggests that one of the behaviors is the cause of the other, or that both are the result of a common cause. That is, that at least one of the behaviors is not random, but is *caused*.

What applies to two series of figures applies with much greater force to three series of figures, or to four, or five, or six.

There is a danger in this reasoning that must be called to your attention: With hundreds of cycles that have been alleged in all sorts of phenomena it would be remarkable if there were not some correspondences of period. However, these matters are relative. Knowing the number of allegations of period to which one has access, it is easy to calculate how often among these periods one could have the same period in more than one phenomenon by chance alone. Similarly, one can calculate the probability of finding, by chance, the same cycle in two, five, or twenty phenomena. Of course, the more phenomena that evidence the same cycle, the greater the probability that the behavior is not chance.

In point of fact, we often do find periods common to many phenomena. Consider for example the 9.6-year cycle, of which 30 examples are listed in Table 3.

It is inconceivable that all these various behaviors could be characterized by cycles of the same period by chance alone. There must be interrelationships or a common cause.

TABLE 3: CYCLES ALLEGED TO BE 9.6 OR 9 2/3 YEARS IN LENGTH IN NATURAL AND SOCIAL SCIENCE PHENOMENA

Science	Phenomenon	Period in Years
Mamma logy	Coyote Abundance, Canada	9 2/3
	Fisher Abundance, Canada	9 2/3
	Lynx Abundance, Canada	9.6
	Marten Abundance, Canada	9 2/3
	Mink Abundance, Canada	9 2 /3
	Muskrat Abundance, Canada	9.6
	Rabbit Abundance, North America	9.6
	Wildlife, Canada	9.6
Ichthyology	Salmon Catches, Canada	9.6
	Salmon Abundance, England	9.6
Ornithology	Grouse Abundance, Canada	9.6
	Hawk Abundance, Canada	9.6
	Owl Abundance, Canada	9.6
	Partridge Abundance, Canada and U. S.	9.6
Entomology	Caterpillar (Tent) Abundance, New Jersey	9 2/3
	Chinch Bug Abundance, Illinois	9.6
	Tick Abundance, Canada	9.6
Dendrochronology	Tree-Ring Widths, Arizona	9.6
Agronomy	Wheat Acreage, U. S. A.	9.6
Climatology	Ozone Content of Atmosphere, London and Paris	9 2/3
	Precipitation, Worldwide	9.6
	Storm Track Shifts, North America	9.6
	U-Magnetic Value	9.6
Hydrology	Run-off, Rihand and Sone Rivers, India	9 2/3
Medicine	Disease Incidence (Human Heart) New England	9 2/3
	Disease Incidence (Tularemia) Canada	9.6
Sociology	War (International Battles)	9.6
Economics	Cotton Prices, U. S. A.	9.65
	Financial Crises, Great Britain	9.6

This identity of period of cycles in different phenomena is true for many periods other than the 9.6-year one, but, as said before, space prohibits giving more than one example for each point to be made.

SYNCHRONY OF CYCLE PHASE

Cycles of the same period tend to turn at about the same calendar time. For example refer to Figure 11 which shows by means of little numbered dots the current ideal timing of the 18 1/3-year cycles that have been discovered in various phenomena. These dots cluster around a mean at 1962.0 Remember that these dots do not represent the actual times of crest of the 18.2-year cycles. They represent the ideal times of crest. They are the times of crest illustrated by the broken zigzag lines to which you have become accustomed in the previous charts.

These ideal timings can be charted at 18.2-year intervals as far into the future or into the past as one might desire. I have replotted them around a mean at 1943.8, 18.2 years previous.

The purpose of charting the ideal timing of these 18.2-year cycles is to illustrate the way in which cycles of the same period turn at about the same time. This is non-random behavior. Sixteen

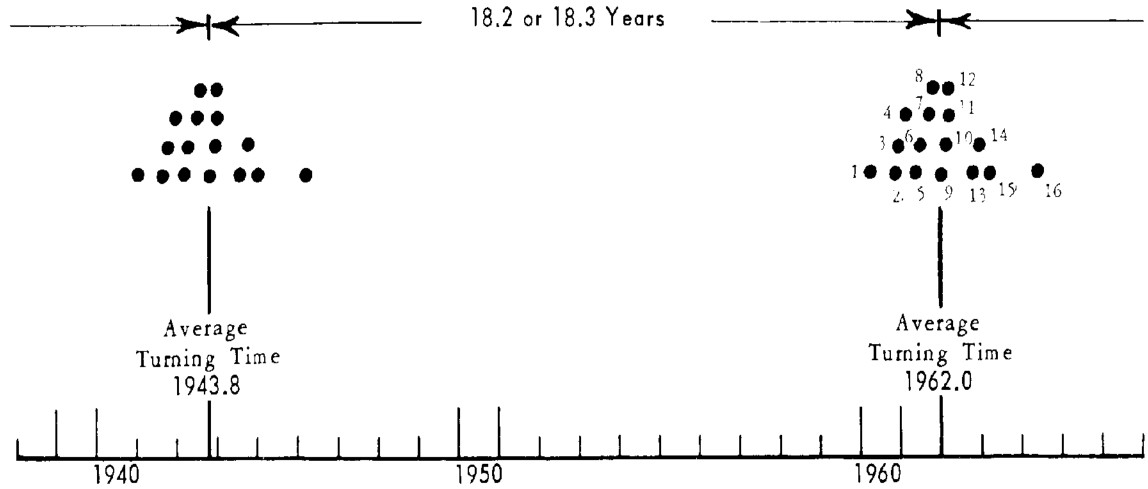


Fig. 11: AN EXAMPLE OF CYCLE SYNCHRONY

This diagram shows, by means of numbered dots, the ideal time of turning of 18.2-year cycles in 16 different phenomena. (The vertical differences of the dots have no significance.) Note the tendency of the dots to cluster about a mean at 1962.0

These dots are repeated 18.2 years earlier, clustering at 1943.8 to show the extent of the synchrony. If the timing were random the dots representing the timing of the 18.2-year cycles would fall haphazardly at any place between any two vertical lines 18.2 years apart.

LEGEND

1. Marriages in St. Louis
2. Nile Floods
3. Sales of an Industrial Company
4. Immigration
5. Sunspots (alternate cycles reversed)
6. Industrial Stock Prices
7. Construction in Hamburg
8. Real Estate Activity
9. Sales of a Public Utility Company
10. Pig Iron
11. Loans and Discounts
12. Many Industrial Companies
13. Residential Building
14. Panics
15. Building Construction
16. Java Tree Rings

NOTE: Many phenomena show several cycles concurrently.

beans scattered at random over a charting of an 18.2-year span of time would not bunch to this extent, except once in a great, great many times.

Incidentally, these particular probabilities cannot be measured mathematically without the assumption that all the crests or turning points should come at exactly the same time. However, this assumption is false. It is easy to see why. The same external cause-if that is what is operative here-will affect one phenomenon first, then another, then another, in the same way that flowers bloom in successive parts of the 12-month seasonal pattern. In fact, an identical cyclic force-let us say winter-will make some things, such as the sales of fur coats, reach a peak; the sales of other things, such as the sales of ice cream, reach a trough.

Similar diagrams can be made for the timing of all the other cycles that have identical periods. As far as this has been done, all cycles of the same period tend to turn at the same calendar time. For example, refer to Figure 12 which gives the concentration of such of the 9.6-year cycles as have been timed.

These facts of identity of period and synchrony of timing explain why, in connection with the analysis of Lake Saki varves, it was possible to postulate the existence of a 17 1/3-year cycle without even looking at the figures.

One can conjecture that there are external environmental forces that play upon all phenomena, just as light of all colors plays upon all things. If so, many phenomena may respond to many of these forces simultaneously, but more strongly to some than to others.

Cycles with periods of 17 1/3 years have been found in many phenomena. When found, they all turn at about the same time. A cyclic element of this period can therefore be assumed to be real. If real, a 17 1/3-year cycle might be present, even if weakly, in many series of figures, and might be detectable in those instances where the series is long enough to eliminate other cycles of nearby period. For the 17 1/3-year cycle, this would require 96 cycles, or about 1,650 years of data. As these were available, I ventured to guess that this cycle might be present in these figures, and it proved to be so.

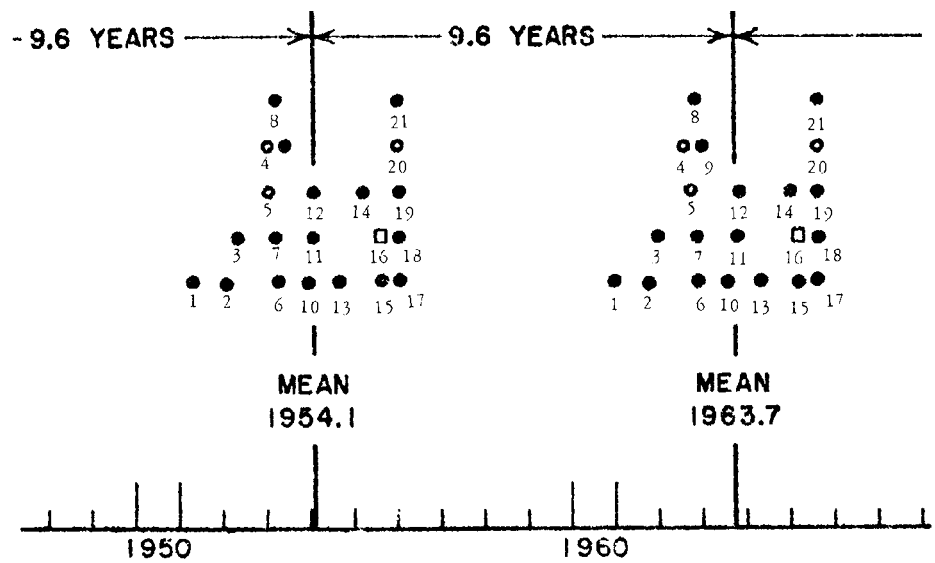


Fig. 12: THE TIMING OF THE IDEAL TURNING POINTS OF 21 DIFFERENT PHENOMENA ALLEGED TO FLUCTUATE IN 9.6-YEAR TO 9 2/3-YEAR CYCLES

Solid dots indicate crests; open dots indicate troughs; the open square indicates the average of the turning points of 45 average 9.6-year cycles in precipitation.

LEGEND

1. Barometric Pressure, Paris
2. Rabbit (Snowshoe) Abundance, Canada
3. Tree-Ring Widths, Arizona
4. U-Magnetic Value
5. Wheat Acreage Harvested, U. S. A.
6. Wheat Prices, Europe
7. Chinch Bug Abundance, Illinois
8. Salmon Abundance, Canada
9. War (International Battles)
10. Lynx Abundance, Canada
11. Salmon Abundance, England
12. Tent Caterpillar Abundance, New Jersey
13. Ozone Content of Atmosphere, London and Paris
14. Heart Disease, New England
15. Rainfall, London
16. Precipitation, 45 Stations, Worldwide
17. Coyote Abundance, Canada
18. Marten Abundance, Canada
19. Mink Abundance, Canada
20. Muskrat Abundance, Canada
21. Run-off, Rihand River, India

The fact that a cycle is present over so long a period of time makes it possible to measure its period with considerable exactness.

SIGNIFICANCE OF RELATED CYCLES

A corollary of the above criteria (identity of period and correspondence of timing) is this: anything which, from internal evidence, increases the significance of any one of the cycles in a group of cycles having identical period and corresponding phase, increases the significance of all the others.

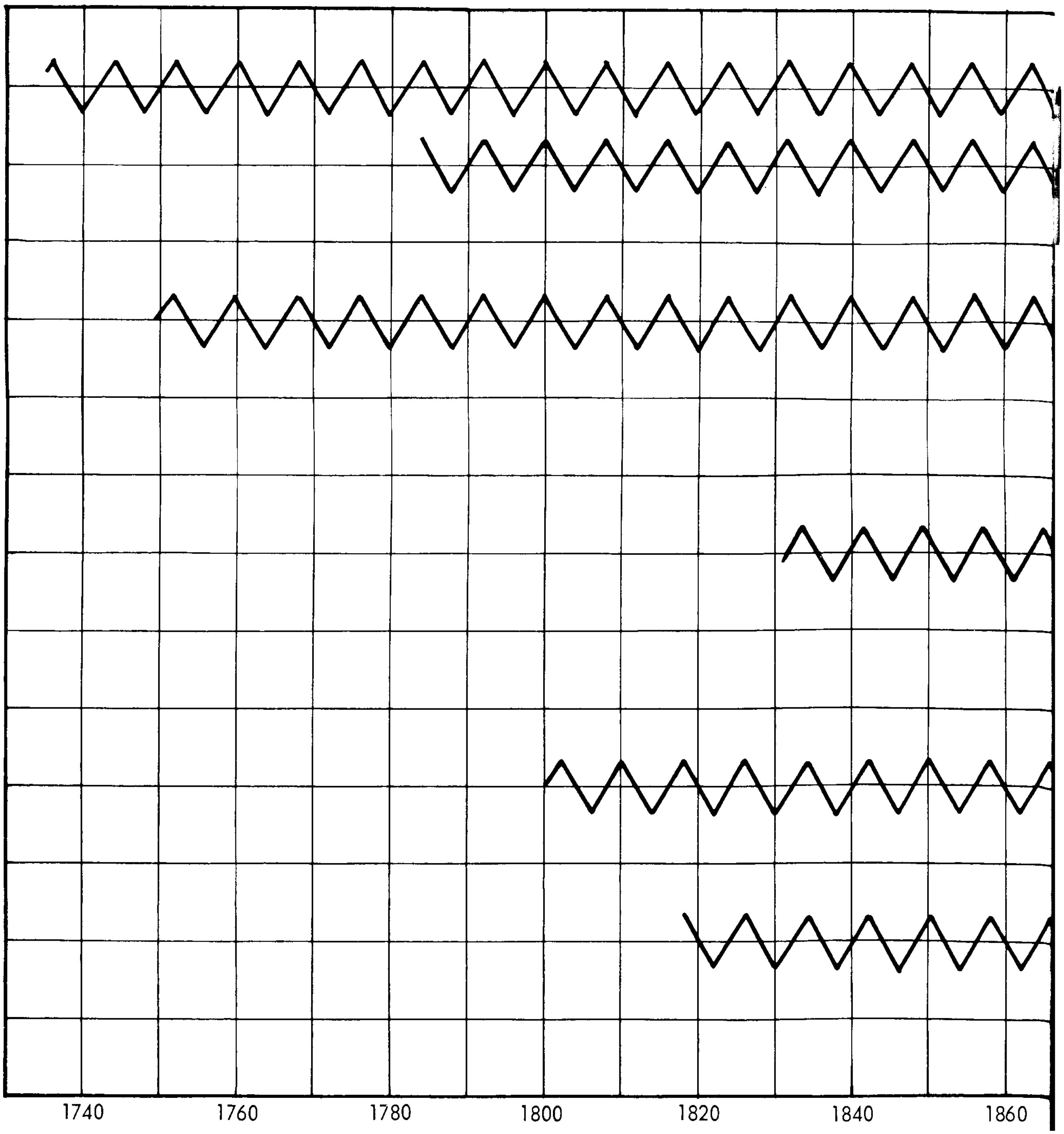


Fig. 13: DIAGRAM TO SHOW THE 8-YEAR CYCLE AS VARIOUSLY ALLEGED (continued next page)

For example, suppose several rather short series of figures all show 4-year cycles. Each cycle, in a way, bolsters each of the others. But suppose the 4-year cycle in one series of figures has been present for 200 years-for 50 repetitions. This one 4-year cycle cannot reasonably be the result of chance. There is, therefore, a non-chance force to which at least some of the other 4-year cycles may be conforming.

Refer now to Figure 13 which diagrams the 8-year cycle as alleged in each of 13 different phenomena. The 3 1/2 repetitions of an 8-year cycle in Goodyear Tire 4t Rubber Company sales could easily have come about by chance, but the 21 repetitions in pig iron prices are significant in their own right. This fact adds credibility to the idea that the 8-year Goodyear Tire & Rubber Company sales cycle may be significant, too. The fact that the 8-year Goodyear cycle crests at

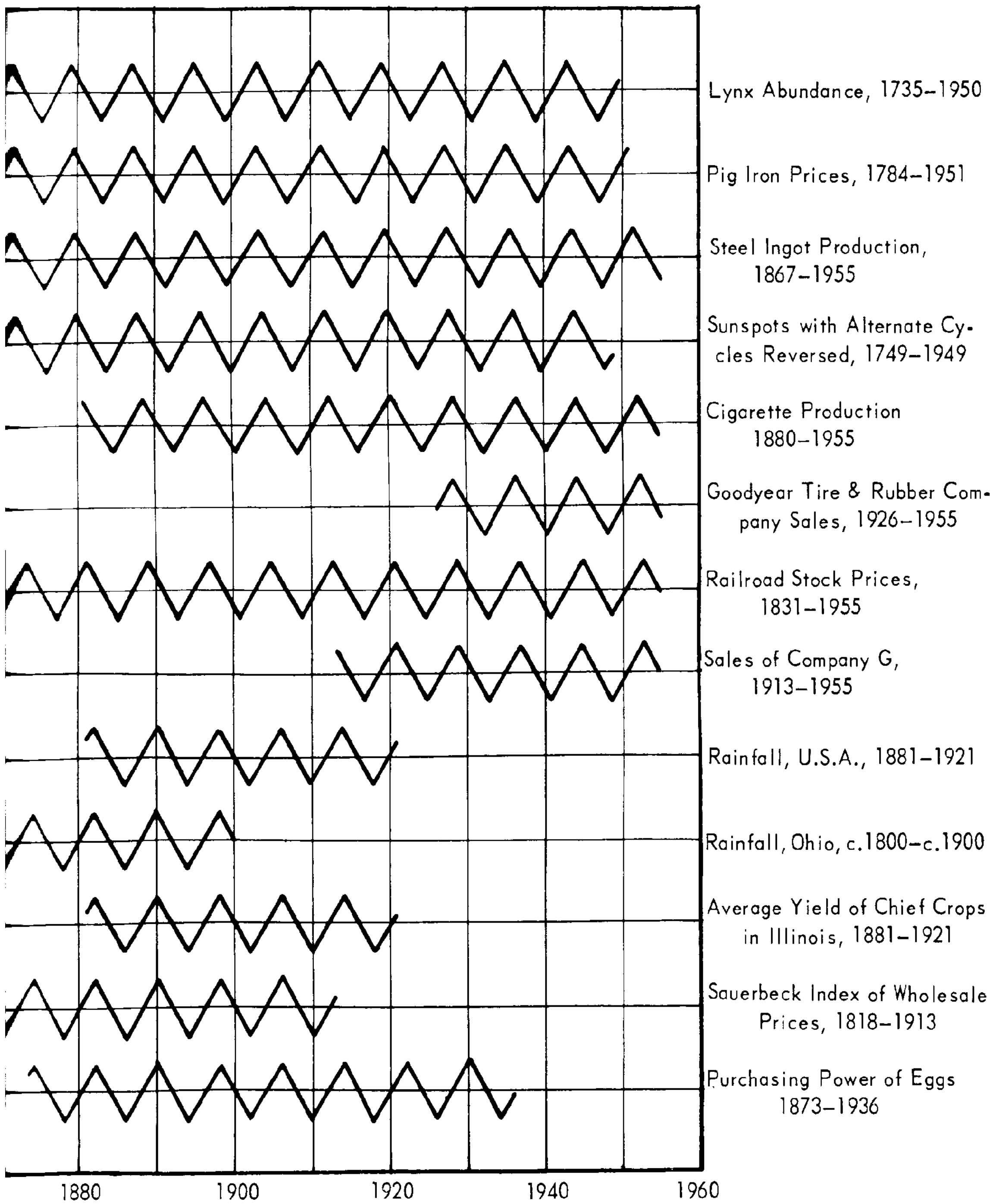


Figure 13 continued from previous page.

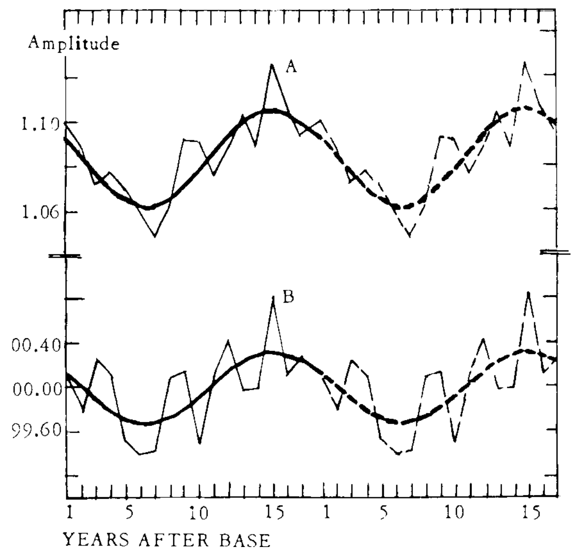
about the same time that the pig iron price cycle crests (and all the other 8-year cycles crest) adds to its credibility.

Note that lynx abundance is listed as having an 8-year cycle, whereas previously it was listed as having a 9.6-year cycle. The 8-year cycle appears as a minor secondary cycle in the lynx figures after an adjustment is made to remove the effect of the 9.6-year cycle. Lynx figures provide another example of a phenomenon that acts as if it were subject to more than one cyclic force simultaneously.

Fig. 14: THE SHAPES OF CYCLES OF THE SAME PERIOD IN DIFFERENT PHENOMENA

The chart shows, by Curve A, the average shape of the 17.323-year cycle in varve thicknesses at Lake Saki for the 4,160-year span 2291 B.C. - A.D. 1869, and by Curve B what seems to be the same cycle in the Flood Stages of the River Nile for the 1,341-year span, 622-1962.

Note the identity of wave shape, even to the serrations.



IDENTITY OF CYCLE SHAPE

The shapes of cycles of the same period are sometimes identical, just as their periods and calendar timings are identical. This is another characteristic that could not easily be the result of chance.

Consider Figure 14 which shows the average shape of the 17.3-year cycle in the thickness and thinness of the Lake Saki varves from 2291 B.C. to A.D. 1869, and the 17.3-year cycle in the flood stages of the River Nile, from 622 to 1962. Note in each instance a fivefold serration, due very possibly to the concurrent presence, in both series of figures, of a shorter cycle.

GEOGRAPHICAL PATTERN

Insofar as the subject has been studied, cycles of the same period will crest later and later as their occurrence is closer and closer from at least the north pole to the equator. In other words, the greater the proximity to the equator, the later the crest. This behavior has become known as latitudinal passage. The change is phase amounts to about 70% of the cycle period in 90°.

Thus, a 10-year cycle which, in one thing, crested at the pole January 1960 would crest in another thing at the equator in January 1967. At north latitude 450, halfway between pole and equator, it would crest 3 1/2 years after the time at the pole, or mid-1963.

Consider Figure 15 which shows the timing of various 4.2-year cycles in weather, tree-rings and other phenomena plotted according to latitude. A definite drift from left to right from the north pole, and perhaps from the south pole too, to the equator is diagrammed by the heavy broken lines.

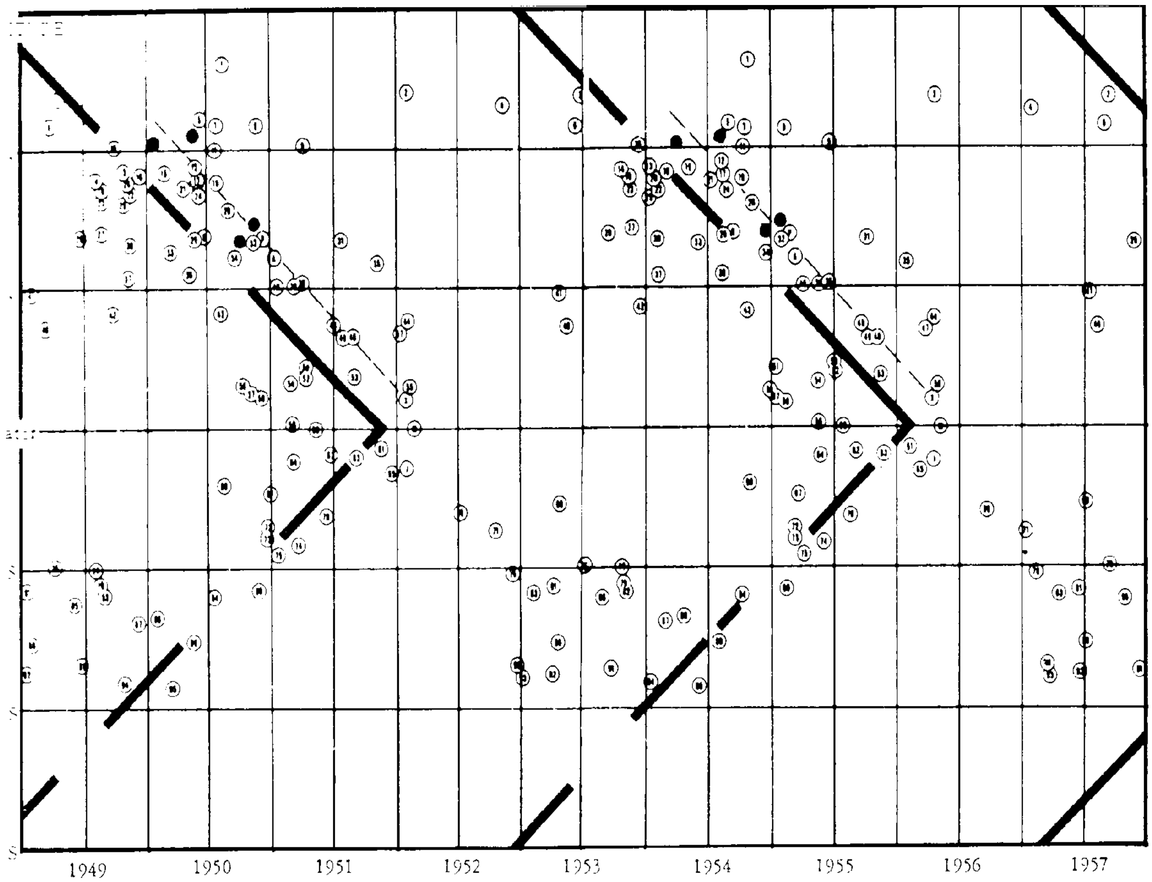


Fig. 15: AN EXAMPLE OF LATITUDINAL PASSAGE

The diagram shows the average ideal timing of lows of 4.2-year cycles in temperature records, and other phenomena at a variety of north and south latitudes.

The vertical scale represents latitude. Numbered circles refer to temperature lows. Lettered circles refer to cycles in other phenomena. Solid lettered circles refer to highs.

Note the tendency of epochs to fall later and later as found from the north pole, and perhaps the south pole too, toward the equator. The slippage amounts to about 70% of the length of the cycle in 900. This tendency was discovered by Dr. Leonard W. Wing, and is called "Latitudinal Passage."

Here again we have ordered, systematic behavior, inconsistent with the idea of chance or randomness. Cycles that evidence geographical pattern are hard to reconcile with mere happenstance.

MAGNETIC DISTORTION

Although, regardless of period, cycles do seem to crest later and later as found nearer and nearer to the equator, this behavior is subject to a certain amount of distortion. For example, consider the 4.2-year cycle. If isopleths are drawn to show the actual dates of crest of this cycle in a variety of phenomena (See Figure 16) we find certain irregularities. These irregularities correspond more or less to the so-called "landmass" distortions of the declinations of the compass needle, but this correspondence may be mere coincidence. See Figure 17.

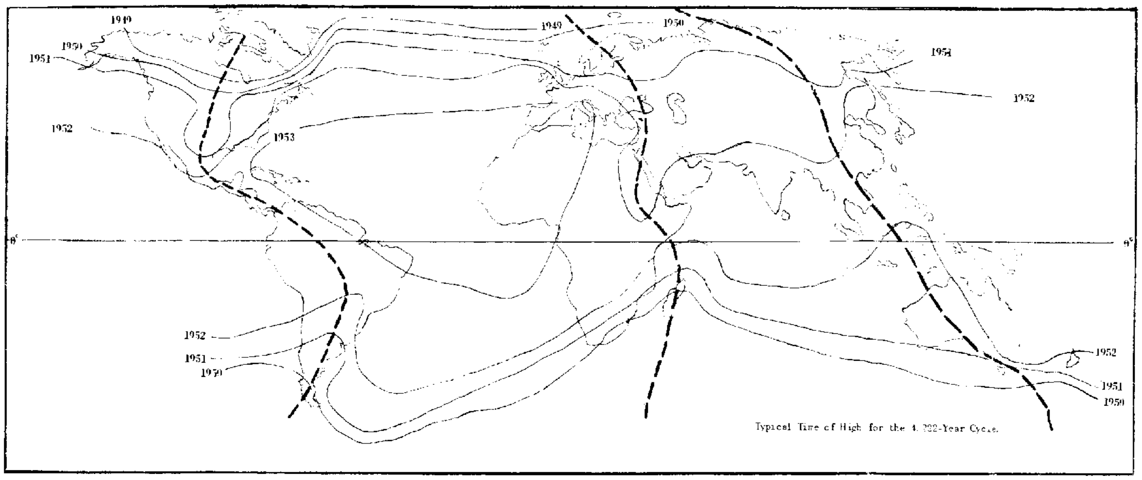


Fig. 16: AN EXAMPLE OF GEOLOGICAL DISTORTION OF CYCLE TIMING

Lines drawn on world maps to show times of temperature cycle highs. The typical time of high for the 4.2-year cycle appears on this map. The dates attached at the wavy horizontal lines show that cycle highs appear first in the polar regions and that they come later and later as we find them nearer to the equator. This behavior is called "latitudinal passage."

The lines bend toward the equator in zones as shown by the heavy broken lines. This means that in these zones, the crests of the cycle move equatorward ahead of the rest of the globe. It is an effect which may be related to landmass. Similar behavior can be noted in magnetic variation. (See Figure 17)

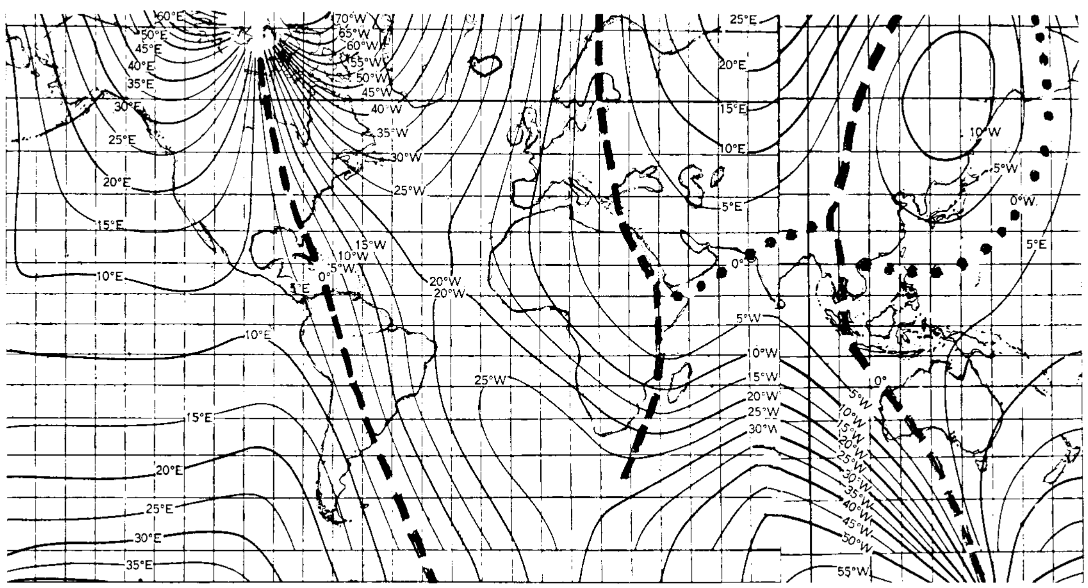


Fig. 17: WORLD MAP OF MAGNETIC DECLINATION

The variation of the compass from true north (declination) shows an influence of landmasses upon terrestrial magnetism. On this map, we have placed broken lines to indicate the zones of zero declination, except in Africa where it marks a zone of minimum relative variation. The similarity of position between these lines and the broken lines of Figure 16 is provocative.

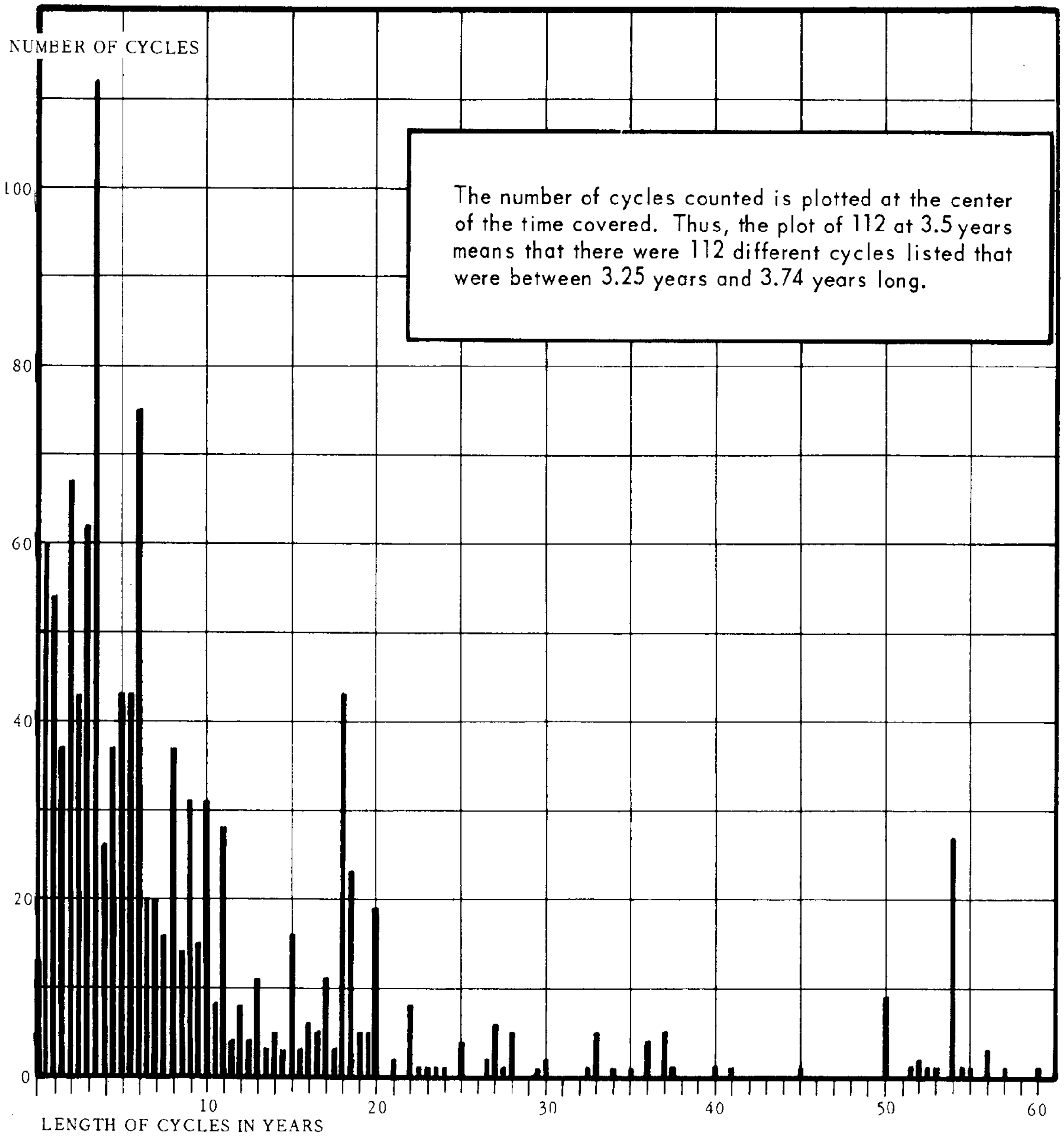


Fig. 18: AN EXAMPLE OF THE FACT THAT CYCLE PERIODS CLUSTER AT CERTAIN LENGTHS IN A NONRANDOM WAY

The chart shows, by half-yearly groupings, the number of economic cycles of various periods. The tendency of many cycles to fall at certain periods and very few cycles to fall at other periods could not occur reasonably in a chance distribution of cycle lengths.

The data were taken from the CATALOGUE OF CYCLES, PART I, ECONOMICS, published by the Foundation for the Study of Cycles. This catalogue abstracts the description of 1,404 economic cycles as alleged in 151 sorts of economic phenomena by 327 different authors.

CYCLE PERIODS CLUSTER

If cycle periods were random and unrelated, and if we were to list these periods by order of length, we would get a fairly smooth distribution. For instance, we would get about as many 15-year cycles as 16-year cycles, or 17-year cycles or 18-year cycles. But when we make the actual experiment we do not get such an even distribution. Refer to Figure 18 which charts by half-yearly intervals the length of all cycle periods listed in the Catalogue of Cycles - Part 1 - Economics. Note the uneven and non-random distribution of periods.

It is clear that something causes this clustering. It is as if there were certain rhythmic forces - for example 3 1/2 years, 6 years, 18 years -to which phenomena tend to conform. It is (is if there were no such forces at 14 years, 19 years, or 21 years.

The distribution of cycle periods is certainly non random, but external cyclic forces are not necessarily the cause of the concentration. The clustering may well be, at least in part, the result of a discovery by one investigator which was copied by others. Or it might be the result of a cycle in some dominant industry that spread to other industries. We must be on our guard against hasty explanations, but the observed concentration of cycle periods is indeed provocative.

FAMILIES OF CYCLES

There is evidence that there are families of cycle periods. That is, if you find a cycle period of one length in one thing (or several things), you will often find a cycle period in some other thing or things that is exactly twice as long. Then you will find another period in another thing-or things-exactly twice as long as that.

This double progression, as it is called, works downward as well as upward. Starting with the origi nal cycle period you will find periods half as long, a quarter as long, an eighth as long, and so on.

Along with double progression you will find triple progression. Cycles with periods three times as long, nine times as long, twenty-seven times as long, and so on; and, going downward, one third, one ninth, one twenty-seventh, and so on.

These behaviors create families o/ cycles, all related to each other by simple numerical relationships. An example of one such family is shown by Figure 19. In this figure the double progression relationships slant, top to bottom, from left to right. The triple progression relationships slant, top to bottom, from right to left. Of the 24 possible periods based upward and downward with 17.75 years as a base, from .22 years to 479.3 years, 18 have been discovered and 6 are still missing.

Figure 19 is supplemented by Table 4 which names the actual phenomena and the periods alleged.

There are two arguments against attaching importance to any such numerical arrangements. The first is that so many cycles have been discovered that it should be fairly easy to find at least one example near almost any length you might wish. The second argument is that many cycle periods have been measured so crudely that it is not possible to say with any assurance that any one cycle period is exactly twice or exactly three times some other one.

The first argument can be met by trying some other progression such as five or seven. You will find that it is not as easy as you might think to find predetermined periods unless you use the factors of 2 and 3.

The second argument is harder to refute. We do not know with absolute assurance the true periods of any except astronomical cycles and the cycles of physics. We may have cycles that

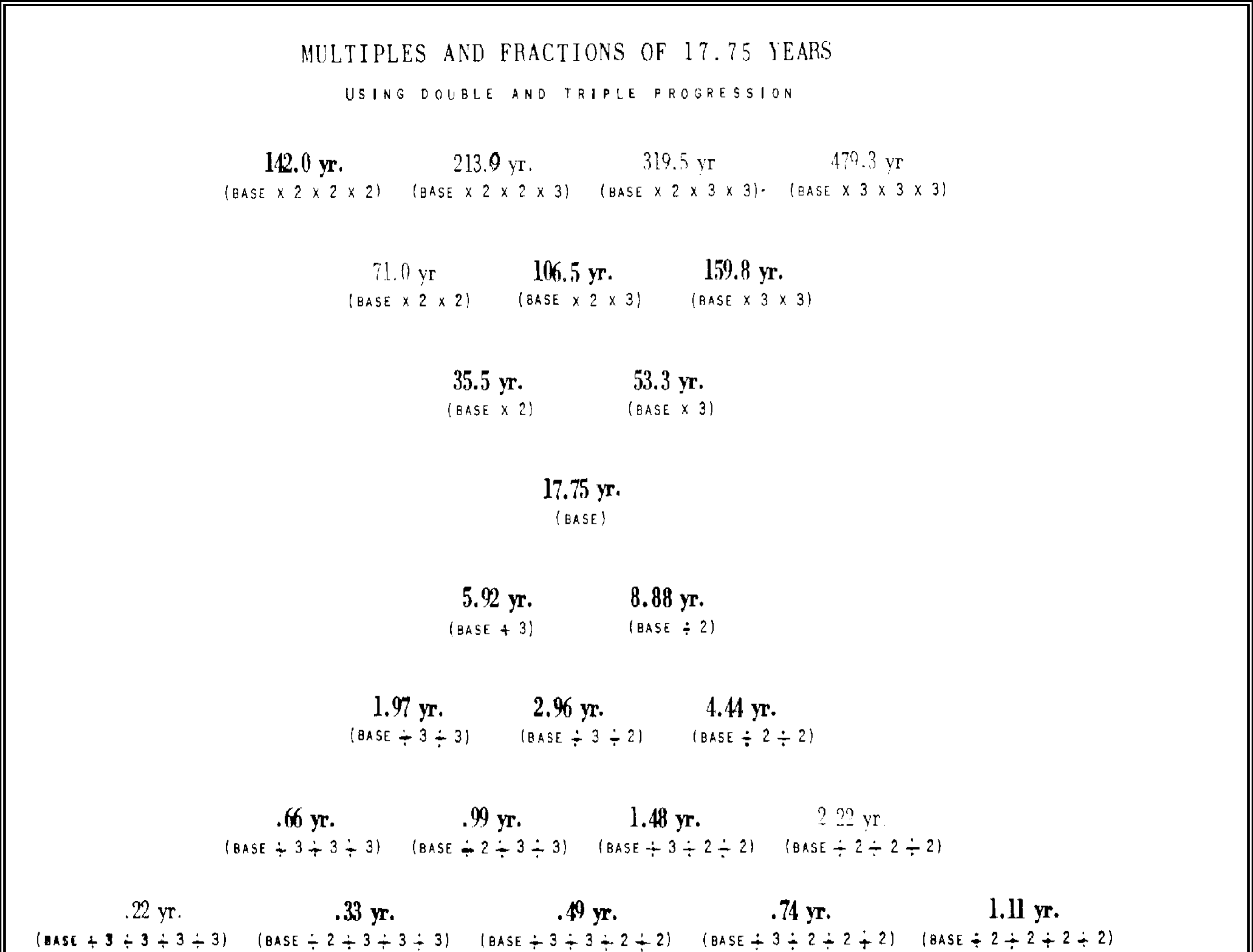


Fig. 19: MULTIPLES AND FRACTIONS OF 17.75 YEARS, USING DOUBLE AND TRIPLE PROGRESSION

The boldface values represent periods for which cycles have been alleged in various phenomena. (See Table 4)

seem to be 7 I/2 years long and other cycles that seem to be 15 years long, but more exact measurement may show the 7 ½-year cycle to be 7.45 years long and the 15-year cycle to be 15.10 years long. In such a case there is of course no simple 1 to 2 relationship.

Much more needs to be done before we can know for certain that families of cycles do exist. In the meantime, the seeming presence of such relationships does add a modicum of strength to the idea that in dealing with cycles we are not dealing with chance behavior, but rather with an aspect of the Universe that is ordered and structured.

To these eighteen criteria we might add perhaps another-common sense. Cycle study is not yet wholly a science. It is still something of an art.

TABLE 4: THEORETICAL CYCLE LENGTHS

(Double and Triple Progression Up and Down Using 17.75 as a Base)

AND ALLEGED CYCLES WHICH ARE IDENTICAL OR CLOSELY CORRESPOND

Theoretical Cycle	Found In	Observed Length
479.3 yrs.	Not yet found	
319.5	Not yet found	
213.0	Not yet found	
159.8	Pig Iron Prices	159 yrs
106.5	Women's Fashions	105
142.0	Number of International Battles	142
71.0	Not yet found	
53.3	Arizona Tree Rings	54
	Prices, U.S.A.	54
	Prices, Germany	54
	Prices, Great Britain	54
	Coal Consumption, France	54
	Coal Production, England	54
	Lead Production, England	54
	Number of Textile Workers, England	54
	Wages of Agricultural Workers, England	54
	Value of French Rente	54
	Value of English Consols	54
	Pig Iron Production, England	54
	Copper Prices, U.S.A.	54
	Cotton Acreage, U.S.A.	54
	Deposits in Savings Banks	54
	Foreign Trade (Imports & Exports)	54
	Interest Rates, U.S.A.	54
	Oat Acreage, U.S.A.	54
	Ship Building, U.S.A.	54
	Devaluation in England	54
	British Wheat Prices	54.0
	Railroad Stock Prices, U.S.A.	54.6
35.5	Abundance of Lynx in Canada	35.2
	Frequency of Aurora	35.9
	Frequency of Earthquakes in China	35.2
	European Weather	35.5
	Barometric Pressure of Batavia	36
	Manufacturing Production, U.S.A.	36
	Wheat Prices in Western Europe	36
	Immigration into U.S.A.	35
	Plant and Tree Growth in England	35
	Thickness and Thinness of Tree Rings in England	35
	Harvests in Europe	35
	Value of English Consols	36
17.75	Industrial Stocks	17.78
	A large mail-order house	17.75
	Failures	17.75
	Sunspots, alternate cycles reversed	17.66
	Pig Iron Prices	17.69
	Cotton Prices	17.75
	War	17.73
	Earthquakes	17.66
	Tree Rings, Arizona	17.75
	Variable Star, Scorpius V 381	17.724

Theoretical Cycle	Found In	Observed Length
8.875	Pig Iron Prices	8.9
	Widths of pre-glacial tree rings	8.85
	Sunspots - Lane	8.76
	Sunspots - Stumpff	8.8
	Sunspots - Clayton	8.94
5.916 yrs.	Cotton Prices	5.91 yrs.
	Pig Iron Prices	5.91
	Copper Prices	5.91
	Sunspots with alternate cycles reversed	5.91
	Tree Ring Widths	5.91
	Railroad Stock Prices	5.9
	Industrial Stock Prices	5.93
	Dozens of other series of figures	6.
	Wheat Prices in Western Europe	5.96
	Liabilities of Failures	5.90
	One half of the time it takes the planet Jupiter to go around the sun	5.931
	One fifth of the time it takes the planet Saturn to go around the sun	5.892
	One forty-second of the time it takes the planet Pluto to go around the sun	5.915
4.438	Sales of Company G	4.37
	Industrial Common Stock Prices	4.4
	Railroad Stock Prices	4.4
	Pig Iron Prices	4.44
	Advertising Effectiveness of Pinkham Medicine Company	4.41
	European Wheat Prices	4.41
	Temperature	4.41
Months		Months
35.5 mo.	Factory Sales of Passenger Autos	36.0 mo.
	Common Stock Prices	35.6
	Common Stock Prices	36.2
26.63	Not yet found	
23.6	Factory Sales of Automobiles	23.6
	Industrial Stock Prices	23.7
17.75	Industrial Stock Prices	17.8
13.31	Industrial Stock Prices	13.3
11.83	Industrial Stock Prices	11.9
8.88	Sales of Company G	8.8
	Bank Debits	9.
7.89	Sales of Company G	7.92
5.92	Electric Potential of Trees	6.
	Industrial Stock Prices	5.9
3.94	Electric Potential of Trees	4.
	Sales of Company G	4.05
	Industrial Stock Prices	3.937
2.63	Not yet found	

SUMMARY

The preceding text, charts, diagrams, and tables have been designed to provide some criteria that can be used to evaluate the significance of cyclic behavior. Applications of these criteria show that at least some of the cycles that we find on every side cannot reasonably be the result of chance.

The thesis is that some cycles beside the daily, yearly, and tidal cycles are caused by something, even if we do not know, as yet, what this something is -or these somethings are.

My exposition would have been much more effective if, instead of limiting my examples to one each, I had shown all known examples of each of the 18 different criteria. Space limitations prevented this because, altogether, there would have been several hundred. The examples presented, therefore, are a very small sample of the multitude which exist.

CAUSE

It would seem to be clear that at least some of the rhythmic cycles cannot easily be the result of chance. This statement also applies to cycles present on the average in each successive part of a series of figures. If not chance, the observed pattern must, by definition, have a cause.

Remember that we are not now talking about the cause of the *phenomenon*, but the cause of the *pattern*. This difference is sometimes not clearly understood. For example, once when I was talking with a vicepresident of a large steel corporation, I showed him the chart demonstrating the dramatic 41-month cycle in the production of pig iron from 1900 up to the date of our conversation-12 upturns, 11 downturns, as shown above in Figure 5 in rate-of-change data.

"Yes," he said. "And I know what caused every one of them."

There is a lot of folklore in business and I take the statement of his omniscience with a grain of salt, but let us not quibble. Let us admit that he did know, in every instance, the immediate cause of each up and each down. What he did not know was why these 23 different causes were all separated from one another at such very regular intervals-in a majority of instances within three or four months one way or the other from perfect timing. Such regularity cannot reasonably be the result of chance. Something different from 23 separate events must have caused -the regularity with which these events befell.

The causes or apparent causes of separate up and down motions of things are legion, but the causes of non-chance rhythmic pattern can be grouped conveniently into two main categories -internal causes and external causes.

INTERNAL CAUSES OF RHYTHM

Internal or endogenous causes can, on their part, be subdivided into those that are inherent in the phenomenon itself and those that are inherent in the interacting system of which the phenomenon is an integral part. The first sort of cause is known as dynamic, the second is called feedback or predator-prey.

DYNAMIC CAUSES OF RHYTHM

Dynamic causes are well illustrated by a weight suspended by a weak coil spring. Once this system is set in motion, the weight will go up and down in a rhythmic fashion. Here the cause is pure dynamics - the nature of the weight-spring-gravity combination itself. Similarly, prices may get too high; then, just because they are too high, fall back and get too low. Then, just because they are too low, they rise, and so on, indefinitely.

FEEDBACK AS A CAUSE

Feedback is illustrated by a thermostat-furnace linkup. In such a system, as you know, when the air in the room gets cool the thermostat clicks, the furnace goes on; the room gets hot, the thermostat goes off; the room gets too cool, and the cycle repeats. Note that in each case the actions are self-defeating, as it were. The going on of the furnace sets in motion a train of events which ultimately shuts it off; and vice versa. The mechanism is more complicated than simple dynamics in that there are two (or more) interacting parts to the system instead of only one.

Under conditions of reasonable uniformity - closed doors and windows and reasonably constant external temperatures, let us say - the regularity of the going on and shutting off of the furnace can be very constant over many repetitions.

PREDATOR-PREY CAUSES OF RHYTHM

Similar to feedback are what are known as predator-prey relationships. In such an ecological system the predator overkills; the prey largely disappear; the predators starve; their absence gives the prey population a chance to recover; the increase of food gives the predator its chance at recovery; it does recover; and the cycle repeats. Here also the time intervals between times of superabundance can be, under constant conditions, very regular indeed.

Dynamics, feedback, and predator-prey relationships are all called "free oscillations." They are undoubtedly the cause of some of the rhythmic cycles that have been observed. But in many instances this explanation will not suffice. For example, internally caused (endogenous) rhythm will not evidence geographical pattern or landmass distortion, will not have the same period in different phenomena (especially in unrelated phenomena), will not synchronize, and, after a distortion, will not normally resume in phase with the pattern evidenced prior to the distortion. In all these instances, and in other instances where no dynamic, feedback, or predator-prey relationship can be discovered, we are forced to look for an external (exogenous) rhythmic cause.

EXTERNAL CAUSES OF RHYTHM

The phrase "externally caused rhythms" refers to those patterns where the rhythm in the phenomenon is the direct result of a rhythm in some other phenomenon. Externally caused rhythms are known as "forced oscillations."

A familiar example is the 24-hour alternation of light and dark created by the time it takes the earth to make one rotation relative to the sun. Another example is the 12-month cycle of air temperature caused by the revolution of the earth around the sun. A third example is provided by the tides which normally are forced by the gravitational pull of the moon into a 12 3/4-hour pattern.

Note that in a forced or exogenous cycle the cause of the cycle is a rhythm or periodicity external to the phenomenon, or to the system of which the phenomenon is a part. However, as illustrated by the example of the tides, the causative rhythm or periodicity need not have the same period as the resultant rhythm.

The mere fact that the cause is external to the phenomenon evidencing the rhythmic behavior does not necessarily make the rhythmic behavior a forced cycle. The wind blowing on dry sand makes beautiful rhythmic patterns, but they are not what are known as "forced rhythms" because the wind is not a rhythmic force. In contrast, consider the waves in sand created by the lugs on the tracks of a caterpillar tractor. Such rhythms are truly forced.

Forced rhythms are very important for two reasons: One, they can teach us of interphenomenonal relationships that might otherwise not be discovered. Two, they lead us to a knowledge of hitherto unknown environmental forces, if such forces exist. Let us consider these two possibilities in order.

INTER-PHENOMENAL RELATIONSHIPS

An industry I could name is dominated by two large companies. Company A knows industry sales from government reports. Subtracting its own sales it can get the sales of Company B, approximately. Cycle analyses of the sales of Company A and of Company B show the same rhythms for each company except that the sales of Company B show an 18 1/4-year cycle not apparent in the sales of Company A. This fact suggested to Company A that Company B had large sales to an industry dominated by an 18 1/4-year cycle. Company A was thus put on notice of the possible existence of a market to which it was not selling, or at least the importance of which it had underestimated.

Another example is provided by a cycle analysis of the index of international battles. This index shows a number of cycles frequently present in economic phenomena along with one found only in biological and climatological phenomena. These facts suggest the possibility that international conflict may have both economic and biological and/or climatological causes.

A third example: there is a cycle in the abundance of ozone in the atmosphere that corresponds to a cycle that has been found in deaths from heart disease. This fact suggests the possibility that the presence of atmospheric ozone may have something to do with the incidence of heart disease.

It should be clearly understood that identity of rhythm in no way proves an interrelationship. The correspondence of period and even the correspondence of calendar timing of the tops and bottoms of the two cycles may be quite accidental, or may be the result of an external cause common to both phenomena. Identity of rhythm per se is merely suggestive.

FORCED VS. DYNAMIC OR FEEDBACK CYCLES

Up to now we have been trying to make the point that at least some cycles are statistically significant - that is, that they cannot reasonably be the result of chance. By now this fact should be abundantly clear. If a hundred examples had been given-as would have been possible, space permitting-we might consider the point proven.

Whenever they are not the result of chance, these rhythmic cycles must have dynamic, feedback, predator-prey or exogenous causes.

How can we distinguish between dynamic, feedback and predator-prey causes on the one hand and exogenous or external forces on the other?

With stable surroundings we can easily imagine great regularity and many repetitions as a result of purely internal forces. Dynamic, and feedback, and predator-prey forces, too, can have great dominance. They could also have symmetrical shape and show themselves to be highly significant mathematically. And why not? They are not chance phenomena. They are significant.

Dynamic, feedback, or predator-prey cycles can also be expected to continue after discovery. They are perfectly real cycles with a cause. Why wouldn't they continue as long as the cause continues?

It will be harder for a dynamic, feedback, or predator-prey cycle to retain exactly the same period over a long span of time, but even this is not impossible. I suspect that sunspot numbers, for instance, may be dynamic or feedback; yet, on the average, they have retained quite a consistent period since about the year 1528.

This leaves us only two criteria from internal evidence alone to judge whether or not the cycle is forced from outside: One, does it continue unchanged through changed conditions? I f the cycle is not changed by changed environmental conditions it is almost certainly forced. Two, after a distortion, does the cycle return to the pattern that prevailed before the distortion? Stop a pendulum. Then start it swinging again. The rhythm will resume, but not in phase, except occasionally by chance in case you have held the pendulum the precise period of a wave, or some multiple of this period. Or, open wide the windows of the room whose heat is controlled by a thermostat. Or rock an animal population by some calamity external to the predator-prey relationship. In none of these instances will the resumption of the cycle ordinarily be in phase. Where we have a return to the old pattern after a distortion we are almost certain to be observing a forced or exogenously caused cycle.

The situation becomes quite different when we consider the evidence produced by comparative cycle study. That is why our knowledge of the basic importance of rhythmic fluctuations never really flowered until (in 1940) comparative cycle study was launched as a separate discipline.

Five of the characteristics of cycles revealed by comparative cycle study well nigh demand the existence of external forces for their explanation. Let us consider these five elements in order.

Cycle Periods Cluster

Unless there were external forces operating, the cycle periods, by the lows of chance, would fall into a reasonably smooth distribution. They don't. Therefore, unless there has been artificial selection on the part of the investigators the causes of such of these cycles as are not random must be external.

Of course the cause could be one of the series that participated in the clustering. However, for all the other series the cause would be external.

Identity of Period

Identity of period involves external forces - unless these identities of period have come about by chance. This is a matter which, in any given instance, can be evaluated by taking into account the total number of periods that have been alleged, and the precision with which the various periods have been measured, the number of cycles that have the given period, and the number of different periods that have multiple representation.

Cycle Synchrony

Cycle synchrony-the turning at about the same time of all the cycles of the same period-as another characteristic that simply could not happen if each cycle were an individual isolated behavior. Unless one cycle caused all the others, or something external to all caused all of them, it would be most unlikely for all of them to turn together. Moreover it is not only all the cycles of one period that do this, but it is all the cycles of any period, insofar as this matter has been studied.

(Mathematics can not help us here because there is no reason to suppose that all the turning points should come at exactly the same time. Mathematical tests based on the assumption that they should are therefore invalid.)

Wave Shape

The identity of wave shape in different series also supports the idea of external cause. That two cycles alone, without compulsion, would have identical and complicated shapes by chance alone is stretching credibility to the breaking point.

Families of Cycles

If there really are families o f cycles, we have strong additional evidence of external forces. Cycles of dynamic, feedback, or predator-prey origin would have periods that would be totally unrelated-except occasionally by chance.

UNKNOWN ENVIRONMENTAL FORCES

The really important aspect of comparative cycle study is the possibility that it will lead to the discovery of hitherto unknown environmental forces that affect life, weather, and many other terrestrial phenomena.

We have seen that many of the rhythms that have been observed in the phenomena around us cannot reasonably be the result of chance. We have seen that many of these non-chance rhythms cannot be the result of dynamic, feedback, or predator-prey situations. A few of the rhythms-but not many-may be the result of inter-phenomenal relationships. (However, this situation raises the question of the origin of the rhythm in the primary phenomenon.) This leaves us with a very large percentage of the non-chance rhythms as necessarily caused by unknown external forces.

Here we come to grips with the central problem of cycle study: What could these external forces be? Unfortunately we do not yet know, but it seems clear that they are something.

If such forces are real, as we said in the beginning, it is a matter of the utmost importance to mankind. The proof of the existence of such forces will push back the frontiers of knowledge as much as any single discovery that I can think of. It will greatly expand man's powers of prediction in both the natural and social sciences. It will make possible a revision and improvement of much of historical, economic, and other thinking and theories. It will demonstrate much greater unity and interrelationship of natural and social phenomena than has previously been imagined. It will have important philosophical implications.

I have presented only a small fraction of the evidence, but I trust it is enough to prove that further exploration in this field is a must.