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CHAOS, CERTAINTY AND CHICKENS

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When the word "chaos" is mentioned, usually the picture that comes to mind is complete disorder and utter confusion.

In the past 20 years, a new science has been developed by physicists and mathematicians which gives a new meaning for chaos.

The mathematical definition of chaos is random behavior in an ordered system. That is, the results of research in the area of physics and mathematics show cases where some responses which appear to be random can be shown to have order.

The phenomenon of chaos was found by Edward Lorenz, a meteorologist. In 1960, Lorenz was examining a computer model of a simple weather system. He found something strange. While inadvertently putting numbers in the program that differed only by less than one part per thousand, he discovered that the resulting weather projections soon diverged farther and farther until they bore no discernible relation to each other.

With this simple model and primitive computer equipment, he had discovered that systems which are described by nonlinear equations can be extremely sensitive to small changes, often resulting in "chaotic" behavior. Linear systems, on the other hand, are more robust in that small differences in initial conditions lead only to small differences in the final result.

Robert May, a theoretical biologist, wrote a paper in 1976 that is now a classic in chaos theory. He gave an example of a simple equation used to study population growth. The equation is X' = AX (1-X), where X' is the population for one year, X is the population of the preceding year, and A is a parameter that varies between 0 and 4.

To examine chaos theory, here is something you can try with your calculator. Or, if you have a computer you might try the following BASIC program:

```
10    INPUT A
20    X = .3
30    For I = 1 TO 150
40    X - A*X*(1-X)
50    PRINT X
60    NEXT I
70    END
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To make things simple, suppose X and X' are numbers between 0 and 1 with the true population a million times these values. Suppose the population (X) is .3 (ie - 300,000) and A = .2. Plugging in the numbers 2(.3)(.7), you get .42. To obtain the next year's population plug .42 (this is the new X or old X') into the formula 2(.42)(.58) or approximately .4872. Using the same procedure, three years and thereafter, the population stabilizes at .5. In fact, whatever the original population size, the population will stabilize at .5. If A is increased to 2.6 the population eventually stabilizes at, approximately, .62.

Now increase the value for A to 3.2. The population no longer stabilizes to one number, but eventually alters between two values, approximately .5 and .8. As you raise the value of A to 3.5 the numbers alter between four numbers, approximately .38, .83, .5, and .88. Increasing the A value a little more causes an alteration between eight numbers. The doubling of the number of values continues as the value for A is increased.

Then suddenly, at approximately A = 3.57, the number of values grows to infinity the population goes into "chaos." The effect is very apparent if it is graphed. All this from the seemingly simple equation AX(1-X).

An interesting attribute of this equation is that there is a paradox to this chaotic behavior. Although the responses appear chaotic over a certain time period, if the responses are plotted as one time period against another time period (X versus X'), a form or structure for the responses becomes apparent.

The discovery of the mathematics of chaos dispels an illusion that mathematics is always certain. In science there is always the goal to define biological organisms and their surroundings in a certain, accurate, and precise manner. While in certain controlled situations mathematics can define outcomes precisely, attempts to model nature and its factors are more complex and variable.

The results of chaos and the behavior of nonlinear systems have implications in a number of fields such as physiology, chemistry, and economics. For example, it has been shown that physiological systems, including the hormone system, heart rhythms, and breathing can exhibit chaotic behavior under certain circumstances.

So what does this have to do with chickens? It so happens that the equation illustrated by May in 1976 is very similar to an equation used to describe growth in animals. This observation has led to studies at Penn State with broiler chickens that have shown that day-to-day growth rate shows evidence of chaotic responses (random but ordered values). These mathematical studies with poultry may give insight into the control of disease conditions such as ascites which are associated with increased growth rate.

For more information on the mathematics of chaos, the books "Chaos: Making A New Science" by James Gleick and "Does God Play Dice: The Mathematics Of Chaos" by Ian Stewart are suggested. Both of these can be obtained from or ordered at your local bookstore.