Comment on Article by B. Cole
Author(s): Deborah M. Gordon
Reviewed work(s):
Source: *The American Naturalist*, Vol. 137, No. 2 (Feb., 1991), pp. 260-261
Published by: The University of Chicago Press for The American Society of Naturalists
Stable URL: http://www.jstor.org/stable/2462116

NOTES AND COMMENTS

COMMENT ON ARTICLE BY B. COLE

Emergent properties seem to be coming back in style, and it may be well to understand exactly what they are. Cole's article (1991) shows that in laboratory colonies of the ant *Leptothorax,* movement occurs in cycles of about 25 min. He suggests that these waves of movement are caused by interactions among ants in which one ant stimulates another to move. This seems a reasonable explanation, both a priori and on the basis of Cole's observations. His results raise some intriguing empirical questions. Motion was recorded, but the activities that led to motion were not observed. The function of the movements that cause ants to interact might reveal the function of the movement patterns of colonies generated by these interactions. Cole further suggests that the cycles of movement should be considered an emergent property of the ant colony. There may be cases in which it is useful to use the notion of emergent properties, but Cole's study is not one of them. The results on colony-level movement patterns are interesting enough as they stand, without requiring any discussion of emergence.

One common misunderstanding of emergent properties is based on a fallacious definition such as "a property of a system at one level of organization is emergent if it cannot be attributed to lower or constituent levels of organization." For example, by this definition, population density would be an emergent property because the notion of density is not applicable to the individuals in a population. But emergence is not an absolute property of a system. Instead, a characteristic of a system is emergent *relative to a particular explanation* (see Hempel 1965, pp. 258–264). Like the tip of an iceberg emerging from the water, an emergent property remains uncovered by a particular explanation. One simple formulation of a correct definition is that some characteristic of a whole is emergent if this characteristic cannot be explained, using a given theory, from what is known of the parts. It is easy to explain population density from what we know of individuals in populations. If density is defined as the number of individuals per unit of area, then density can be explained by counting the number of individuals, measuring the area they occupy, and dividing the first number by the second. Density is a property of populations, not individuals, but it is not an emergent property.

Cole's use of the notion of emergence does not make this mistake, but it is flawed in a more subtle way. The correct definition above draws attention to the important problem of what is meant by "whole" and "parts." To paraphrase Cole's argument: ant colonies show cycles of movement; isolated ants do not show such cycles. Thus, he says, movement patterns of whole colonies are emergent because they cannot be explained as the sum of the movements of parts of

Am. Nat. 1991. Vol. 137, pp. 260–261.

colonies, namely, isolated ants. The problem is that this is not a useful test of emergence. To test whether movement patterns of colonies are emergent in any interesting way, it would be necessary to sum the movement of individual ants *in the colony*.

Consider the noise made by a crowd at a football game. Suppose spectators are asked to sit alone in an empty room with a view of the game. The summed amount of noise produced by a large number of spectators alone in empty rooms does not equal the decibel level of audiences while the game is going on. Is the noise level at football games an emergent property? No, because people do not often shout when sitting alone in rooms. A better test of the claim of emergence would be to measure the amount of noise that individuals make *in the crowd* and then sum those individual measurements.

What this example has in common with that of ant colonies is that the relation among the parts is what causes the characteristic claimed to be emergent. Solitary spectators and isolated ants do not behave in the same way in their isolated state as each would when part of the crowd or colony. Solitary spectators do not always respond aloud to the rhythm of shouting that accompanies a football game. Isolated ants tend to remain motionless.

Perhaps this is exactly what Cole wishes to emphasize with the term "emergent property": the cycles of movement are a consequence of interactions among ants. This is an important point, even if an obvious one. But if the term "emergent property" is used in this way, almost anything true of any aggregate would be an emergent property. A house will not keep out the rain if it is laid out as a pile of bricks, wood, and glass. A tree's leaves will not turn red in the fall if they are pulled off the tree in the summer. A dog's tail will not wag if it is cut off the dog. But if demolition or excision are used to show that watertightness, fall foliage, or tail wagging are emergent properties of houses, trees, or dogs, then "emergent" does not mean much. Correctly used, the term refers to more than the existence of interactions among parts. In the case of Cole's work, the pattern of movement in a colony would be emergent if it could *not* be explained in terms of interactions among ants in the colony. In fact, he shows very well that the pattern can be explained in exactly this way.

LITERATURE CITED

Cole, B. J. 1990. Short-term activity cycles in ants: generation of periodicity by worker interaction. American Naturalist 137:244–259.

Hempel, C. G. 1965. Aspects of scientific explanation. Collier-Macmillan, London.

DEBORAH M. GORDON*

DEPARTMENT OF ZOOLOGY
UNIVERSITY OF OXFORD
OXFORD OX1 3PS
ENGLAND

Submitted November 9, 1989; Accepted November 10, 1989

* Present address: Department of Biological Sciences, Stanford University, Stanford, California 94305.