Book Reviews

PROBABILITY AND PREJUDICE

Mathematical Ideas in Biology

By J. Maynard Smith. Pp. vii + 152. (Cambridge University Press: London, November 1968.) 30*s* cloth; 12*s* paper.

THE author's aim with this book is primarily to introduce biologists to some of the mathematical ideas arising in biology, and the mathematical level has been kept deliberately elementary. There are some interesting arguments based on scale in chapter one. Population regulation through density-dependence, competition and predator–prey relations is discussed in chapters two and three (discrete generations in chapter two, continuous time models in chapter three, treated deterministically). Probability is introduced with the genetics of families in the fourth chapter; simple population genetics in chapter five, models of irradiation effects in chapter six; control theory applied to muscular movement and to protein synthesis in chapter seven; and reference is made in chapter eight to two-dimensional diffusion models of morphogenesis.

There is no doubt that this book achieves its aim, and incidental criticism is not intended to question its general value. The coverage is of course so wide as to be necessarily sketchy. The author is therefore perhaps justified in excluding bio-statistics as already covered elsewhere, though if this suggests a hard-and-fast division this would be unfortunate. Probability is given a frequency interpretation and the binomial and Poisson distributions subsequently derived in chapter four, but this inevitably introduces statistical ideas. (What, for instance, is the first example on page 96 but a question in statistics ?). The omission of the normal (Gaussian) distribution seems a pity, especially in view of its relevance for diffusion processes.

It is stated in chapter five that the Hardy–Weinberg ratio is true only if mating is random. The word "only" should be deleted. The calculations in Table 1 on the number of generations required for a given change in gene frequency under selection pressure become of dubious value at the extremes, as the effect of finite population size has been ignored.

The last example on page 70 has nothing to do with probability as frequency, and requires detailed comment. The author says it nearly wrecked a conference on theoretical biology, but he also says that it yields at once to common sense or to Bayes's theorem. If it is so simple, this does not seem to say much for the conference participants; moreover, as a question on Bayes's theorem, the answer given may legitimately be questioned. The example is as follows:

> "Of three prisoners, Matthew, Mark and Luke, two are to be executed, but Matthew does not know which. He therefore asks the jailer 'Since either Mark or Luke are certainly going to be executed, you will give me no information about my own chances if you give me the name of one man, either Mark or Luke, who is going to be executed'. Accepting this argument, the jailer truthfully replied 'Mark will be executed'. Thereupon, Matthew felt happier, because before the jailer replied his own chances of execution were $\frac{2}{3}$, but afterwards there are only two people, himself and Luke, who could be the one not to be executed, and so his chance of execution is only $\frac{1}{2}$.
>
> "Is Matthew right to feel happier ?"

The individuals to be executed are already determined and known to the jailer, who is therefore justified in passing on as irrelevant to Matthew the name of either Mark or Luke as one of these. It is said, however, that Matthew is prepared in the absence of this certain knowledge to allocate numerical probabilities to possible eventualities as indicated. Is he being consistent in his assessments ? Suppose the prior probabilities are denoted in general by p, q and r respectively for Matthew's, Mark's or Luke's survival. Then the posterior probability of his own survival after the jailer's information is from Bayes's theorem changed from p to $p' = pP/(pP+r)$, where P is the probability of the jailer naming Mark if both Mark and Luke are to be executed. Note that *to the jailer* either p or r is 1, and in either case (whatever P) there is for him no change in p. Now *if* Matthew assigned values $p=q=r=\frac{1}{3}$, $P=\frac{1}{2}$, then also for him $p'=p$, and he was behaving inconsistently in claiming $p'=\frac{1}{2}$. But he is quite justified (consistently with the wording of the example) in first assigning $p=\frac{1}{3}$, $p'=\frac{1}{2}$, provided he then chooses $r/P=\frac{1}{3}$. His assessments are now all consistent, and, as $p'>p$, he has a perfect right to feel happier !

If the example proves anything, it is the indefiniteness of subjective prior probabilities. M. S. BARTLETT

PROBLEMS OF MOTION

Modern Science and Zeno's Paradoxes

By Adolf Grunbaum. Pp. x + 153. (Allen and Unwin: London, November 1968.) 32*s*.

DURING the period 490–430 BC (approximately), there lived a truly remarkable man, Zeno of Elea, a close disciple of Parmenides, who shook the contemporary philosophers by asserting that geometry was essentially paradoxical, which made it impossible to enact a science of motion which should be free from contradictions. It seems unlikely that mathematical concepts could have received such a blow again as that delivered by Kurt Gödel a few decades ago. This alone is some measure of Zeno's intellectual stature, even though some of his breakthrough may have been accomplished by members of some associated school. Indeed, the spectre of paradox has always belaboured the efforts of logicians; for example, the famous "tortoise" (Zeno's own), "the liar", and those of Richard and Russell in more recent times.

In Greek thought, the work of atomists like Empedocles and Heraclitus became suspect as they needed support for their basic notion of motion. Very properly, the author of the present book deals with the problem of motion before that of extension. Thus, chapter one discusses the nature of temporal becoming, chapter two, Zeno's paradoxes of motion, and chapter three, his metrical paradoxes of extension. There is an adequate bibliography and index, the former especially welcome because much of the relevant literature is hard to discover.

In essence, chapter one examines the temporal status to which perceptual experience is entitled with particular reference to physical indeterminism. It is well to reflect that classical physics would never have bothered about it at all. Heisenberg's principle has forced the issue on the attention of men of science. Chapter two is very relevant to this development, including the problem of "infinity machines". As his earlier pages predict, Grünbaum reserves to the end the elaboration of Zeno's own thought on the subtle character of extension.

All this leads one to ask whether or not the present somewhat static condition of physics is due—at least in part—to the neglect of these fundamental issues. So long as "it works", technologists' questions will never reveal the underlying epistemological difficulties of natural science. It is not their affair. But Grünbaum's approach is much nearer that of Polanyi's *Personal Knowledge*. Further-