elementary scientific terms. Similarly, of a sample of young engineers: "Aesthetically, the minds of the weakest among them might almost be described as *tabula rasa*".

Secondly, what in a way is even more disconcerting: the average sixth-former's test scores go on rising during his last three years at school, but they do not rise while he is at university. The average arts score among undergraduates is almost exactly the same as that among sixth formers (even though the former are more highly selected), while the average science score is only marginally higher. In other words, the student's general education, such as it is, seems to cease when he enters university. His specialized work there leaves him no time to familiarize himself not merely with subjects distant from his own, but those which are his closest neighbours in the cultural spectrum. The history specialist learns nothing new about literature, let alone about science; the physicist learns nothing about biology, let alone about the arts. It is sometimes held that university is a 'broadening' experience. These results indicate that if broadening does occur, it is not of a kind that reflects itself in general knowledge.

These results confirm some of one's worst suspicions, without—understandably—telling us how the situation might be improved. Should we attempt to 'broaden' some, or all, of our students? Should we tackle the problem by broadening the curriculum, or by 'additives', or by some other means? Conversely: Do we accept narrow speculation in the majority of students as inevitable, and try—with Dr. Leavis—to train a new race of critics, or cultural middlemen?

Mr. Richmond's book is a first step towards the rational solution of such questions. Not merely does he dispel complacency; he provides, in prototype, tests which should eventually help us to measure whatever benefits, apart from technical competence, our schools and universities bestow.

L. Hudson

GROWTH OF SCIENTIFIC KNOWLEDGE

Conjectures and Refutations

The Growth of Scientific Knowledge. By Karl R. Popper. Pp. xii+412. (London: Routledge and Kegan Paul, 1963.) 55*s*. net.

LONG before the present-day fashion of having recourse to an anti-world, Prof. Popper—or rather the popular image of him—had emerged as an anti-x, where x successively took the values 'induction', 'Bacon', 'verificationism', 'Wittgenstein', 'Plato', and 'historicism'. That the problem which ultimately led to his various *démarches* was concerned not with opposition to anything but with finding a criterion of demarcation between the statements of the empirical sciences and all other statements was made clear in a lecture delivered in Cambridge in 1953 (No. 1 of *Conjectures and Refutations*). Here he shows that the confusion had probably arisen from the fact that his first results were published in the form of a criticism (*Erkenntnis* 1953) of Wittgenstein's criterion of meaningfulness. The confusion was not wholly dispelled by the publication of his book *Logik der Forschung* (1954). Thus far the whole discussion had been carried on in German, and at a time when exchange of ideas between Great Britain and Vienna was even more than normally restricted. After repeated entreaties and some considerable delay *Logik der Forschung* appeared in English as *The Logic of Scientific Discovery* (a not altogether happy rendering) in 1959. In this extremely important work the task of the newcomer to Popper's critique is made almost impossibly difficult by a complex apparatus of additional footnotes, appendixes and notes to appendixes, some of which contained references to a postscript advertised as "in preparation". To those unfamiliar with the work of one of the most challenging and influential thinkers of our time, as well as to others who have failed to set it in a satisfying perspective, *Conjectures and Refutations* will be doubly welcome.

After a brief explanatory preface and the admirable British Academy Lecture on the "Source of Knowledge and Ignorance", there follow ten 'conjectures' (including the 'personal report' already alluded to), as many 'refutations', six technical addenda, and two well-constructed indexes. The division into 'conjectures' and 'refutations' seems to be based on little more than emphasis: in the 'conjecture', "Back to the Pre-Socratics", for example, the author refutes with his customary, and not altogether convincing, gusto the Baconian myth (Did not Bacon himself write "to conclude upon an enumeration of particulars without instance contradictory is no conclusion but a conjecture"?); in the 'refutation', "Utopia and Violence", he admits that his "rationalism rests on an irrational faith [conjecture?] in the attitude of reasonableness" (p. 357).

One may agree with the author that all are "variations upon a theme", though with less assurance that it is "very simple"—"the thesis that we can learn from our mistakes". This is indeed obvious *a posteriori*, since we do not continue to "make mistakes" in inferring the outcome of the repetition of the 'same' set of circumstances. But what Popper takes as the indisputable concomitant (it is not always quite clear whether as antecedent or consequent), namely, that all investigation starts with 'hypothesis', 'observation' being resorted to only as a means of 'falsification', seems far from 'simple'. It could be so only if we were all agreed as to what constitutes 'observation'—persistence in the traditional agreement being possible only by ignoring the revelations of experimental psychology. Popper is, of course, aware of this (for example, p. 47 and p. 55), but scarcely comes to grips with the experimental determinant of choice among 'possible' hypotheses. Shifting the ground to a 'problem-situation' is all very well; but how do we recognize a 'problem' except as a consequence of some generalization —call it 'induction' or 'custom' as you will? At the logical level, Popper states that the "criterion of the scientific status of a theory is its falsifiability or refutability or *testability*" (p. 37, italics mine). This seems to be a tacit weakening (in the logical sense) of the sole criterion of falsifiability which it has been generally assumed he had previously demanded. If the former correctly represents his position, it narrows the gap between him and other critics of 'Classical' logical positivism, such as Mehlberg.

I have directed attention to a few points of possible disagreement mainly as a warning against the assumption that there can be no middle way between the naïve belief in the "certainty of the exact sciences derived from observed facts by induction" and the strongest expression adopted by Popper: "Only the falsity of the theory can be inferred from empirical evidence and this inference is a purely deductive one" (p. 55). However far the reader may be prepared to go towards accepting Popper's theme, he is strongly advised to take this opportunity of studying the variations—the Pre-Socratics; Kant's cosmology; tradition; the mind–body problem; dialectic; prediction in the social sciences; public opinion; Utopia and violence; and others—all are full of valuable insights lucidly and persuasively expressed, and their relation to science and philosophy examined. It is difficult to imagine any kind of reader who would not derive from these pieces a liberal education in the sense that Prof. Popper would wish that term to be understood.

It only remains to add that most of those already published have been "revised, augmented, and re-written" (model bibliographical notes to each piece are provided); four chapters and the addenda are published for the first time. I noted a dropped letter on p. 385; and 'Wright, H. M.', should read 'Wright, E. M.', both on p. 83*n* and in the index.

William P. D. Wightman