

of events just mentioned does not occur. An increase of temperature will now merely increase the pressure inside the star, so that the star expands and cools. By this thermostatic mechanism, the star continually adjusts itself so that just enough energy is generated to replace that lost by radiation. From its nature the adjustment cannot usually be instantaneous, so it is perhaps not surprising that the stars which are cooler than 'main sequence' stars are mostly variable stars in which regular and substantial fluctuations of light occur.

Thus we think of the matter of the primeval universe as having first condensed to form separate detached masses, one of which ultimately formed our galactic system. This process may well have taken tens of thousands of millions of years. These distinct masses in their turn broke up into separate stars, taking perhaps hundreds of millions of years to do so. These stars would at first be cool, of low density and of immense size. After contracting for a few million years, they attain a temperature at which the proton-proton reaction begins to occur. But at low temperatures this reaction occurs but rarely—too infrequently to make good all the energy lost by radiation. The stars accordingly continue contracting until they attain temperatures at which the protons react to an appreciable extent with the nuclei of light elements. This reaction may supply radiation for a few million years, after which the light elements are used up; then contraction begins afresh and continues until the temperature of 20,000,000° is reached. The carbon reaction now takes control and can supply radiation for thousands of millions of years if the star is not too massive and luminous. During this period, the proton-proton reaction still occurs, and may provide for an appreciable part of the star's radiation—perhaps for half in the sun, and for even more in less massive stars. Finally, the supply of protons gives out, and the star contracts once more—possibly for hundreds of thousands of millions of years.

At some point in this sequence of events the sun has given birth to planets; at some point other stars may do the same. Mathematical investigation shows that planets can be born out of a star by tidal action—through a second star approaching near to it and drawing out a long filament of gas, which then breaks up gravitationally and condenses into separate planets. If the two stars are of similar build, such an event requires an approach to within about three radii, whatever the sizes of the stars may be.

Approaches of the requisite closeness would clearly be far more frequent in the early period when the stars were big, than in the later period when they were compact. For our sun, the first period was short (less than 20 million years), while the latter period has been long (more than 2,000 million years). Nevertheless, calculation shows that an effective tidal encounter is far more likely to have occurred in the former short period than in the latter long period. It is not surprising, then, that the solar system is found to contain intrinsic evidence that its planets were born while the sun was still of immense size. It must have extended an appreciable fraction of the distance to the present orbit of Pluto: otherwise there would have been no mechanism for putting the outermost planets in their present orbits.

It follows from this that the age of the sun as a star is approximately equal to the age of the earth as a planet—probably between two and three thousands of millions of years. In this period, the sun can only have used up a small fraction of its protons, so that

it probably can look forward to a life in its present state which will be incomparably longer than the life that lies behind it. When this is over, it will begin to shrink into a smaller and cooler star, and life on earth will become impossible.

Detailed calculations show that the chance that a star shall give birth to planets while it is of the compact dimensions of our sun is quite negligible. On the other hand, the chance of its having given birth to planets before attaining to this state is considerable—a fair proportion of the stars must, then, be accompanied by planets. Of these a substantial fraction are likely to be in a physical state not very different from that of our own earth, and so capable of maintaining life like our terrestrial life; it is possible that such life is far more abundant in space than we used to think.

PREVENTION AND TREATMENT OF ANTI-SOCIAL BEHAVIOUR

IN his Chadwick Lecture on "The Differentiation, Prevention and Treatment of Anti-Social Behaviour Disorders" delivered on December 8, Dr. Norwood East has made a succinct but systematic review of the main established facts regarding the causation of crime, and has presented a convincing argument for the view that crime is as much a scientific as a legal or a medical problem. Dr. East was for many years one of H.M. Commissioners of Prisons, and Medical Inspector of Prisons in England and Wales. He has recently completed a scientific study on an extensive scale of the medical, social and psychological aspects of crime, more particularly among adolescents (see NATURE, September 26, p. 361). He is therefore able to speak both with experience and authority; and much of his lecture is in fact concerned with the practical corollaries to be deduced from the inquiries that he has made.

Generally speaking, Dr. East regards behaviour disorders as manifesting in nearly every case a complex causation. They are "the result of stress, acting upon an inherited constitutional pattern, which may itself have been modified, in varying degrees, by environmental factors other than the stress itself". The inherited constitutional factors are themselves incapable of being greatly changed. It follows that, in general, the treatment of anti-social behaviour must be limited to efforts at changing the environmental factors, and particularly to relieving whatever stress may have precipitated the criminal action. In different cases, however, the relative importance of the constitutional factors, on one hand, and of the environmental factors, on the other, may differ widely. Thus, although individuals belonging to certain temperamental types may be more liable to yield to temptation than persons of average mental heredity, nevertheless, "the majority of persons, and perhaps all, are potential first offenders"; for criminal action, as a rule, results, not from one type of factor to the exclusion of the other, but from "a disturbance of the balance between the two".

According to Dr. East, therefore, the fundamental psychological premise from which the criminologist has to start is the fact that "no person corresponds exactly to his fellows; for even an arbitrarily selected normal person occasionally shows peculiarities of behaviour". Consequently, while anti-social behaviour

may be precipitated by almost any form of maladjustment between the individual and his environment, some individuals, by nature or by habit, will be more prone to disregard the requirements of the society in which they live, and so more easily led into actions which that society regards as criminal. This is especially true of those suffering from mental defect or mental disease. Much of his lecture is, therefore, devoted to the relation of crime to these particular pathological conditions.

Among inborn factors, the most important in his view are the inherited "drives", a term which he borrows from American psychologists to denote "the impulsive energy of any instinct". In guiding social behaviour, he holds, the acquisitive, sexual, gregarious and self-preservative instincts prove to be exceptionally powerful; and he argues that "much practical insight into normal and abnormal motivation is gained by regarding the various instincts and their accompanying emotions as the basic essentials of purposive action". But instinct is not all. Intelligence, as the psychologist defines the term, is equally an inborn factor. Differences in innate intelligence may limit the powers of self-control and of learning by experience. Hence individual intelligence has also to be taken into account in considering motive or lack of motive, and in proposing suitable treatment. In particular, as he points out, "it is characteristic of much anti-social behaviour that the desire of the moment, the proximate aim, is more importunate and decisive than a long-term ambition or desire".

Children and adolescents, owing to their immaturity, are largely under the sway of their innate impulses; and, particularly if brought up under adverse home conditions, may be slow in learning to control their conduct by intelligence or experience. Hence, during childhood and puberty, many forms of behaviour may arise as part of the normal development of the growing boy or girl which in an adult would be looked upon as criminal. In discussing the treatment of juvenile delinquents, Dr. East briefly notes the valuable part that may be played by child guidance clinics both in prevention and cure; and is apparently inclined to attribute much of the delinquency that is rife among children at the present day to ignorance of "even elementary standards of conduct". As to the means of combating this ignorance, he cites the view of the Middlesex Education Committee, which urged that "religious education was the surest means of acquiring these standards", and reported that teachers themselves were showing "considerable enthusiasm for this branch of education".

Since criminality is more apt to arise in persons of abnormal mentality, Dr. East, like most medical investigators, has paid special attention to the association of anti-social behaviour with insanity, with mental deficiency, with neuroses, and with psychopathic states; and quotes authoritative figures. "Although no particular crime is characteristic of insanity, the proportion of homicides in this country who are insane is much greater than the proportion of those who commit other offences"; but "criminal conduct associated with insanity may extend almost throughout the whole gamut of crime". The forms of major mental disorder chiefly associated with crime are schizophrenia, manic-depressive disease, and paranoid states; and since in each of these conditions inheritance appears to play an appreciable part, eugenic marriages, he argues, may tend in some degree to diminish the number of offspring liable to

develop anti-social behaviour. However, as he goes on to point out, the frequency of definite insanity among criminals is exceedingly small: the number of persons received into prison who are either insane on reception or become insane during detention is barely 1 per cent of the admissions.

Mentally defective criminals are even fewer; they form only half of 1 per cent of the admissions. However, the higher grades of mental deficiency shade off imperceptibly into normality through a sub-normal group, who may also display anti-social behaviour. The mentally deficient "commit various crimes including murder at one end of the scale and vagrancy at the other"; but "the majority of their offences are connected with the acquisitive instinct, namely, theft, embezzlement, false pretences and the like; next in frequency are various sexual offences; but, as with insanity, no particular kind of crime is characteristic of the condition". The defective offender, however, very easily forms a criminal habit; and the danger to the community from his misconduct is to be measured, not merely by a particular offence, but by his incorrigibility. Hence the importance in these cases of enforcing early institutional care. A large measure of prevention has already been secured by prompt ascertainment, followed by segregation or supervision; but, it is argued, if eugenic principles could be applied, still more anti-social behaviour would be prevented.

Since psychoneurosis is often precipitated by emotional maladjustment, it is not surprising to find that many criminals show neurotic symptoms. Here precise figures are harder to obtain. Hysteria, Dr. East believes, is far more frequently associated with major forms of anti-social behaviour than is sometimes supposed. Anxiety states, too, may often form the chief cause. On the other hand, contrary to notions prevalent among the general public, obsessive and compulsive states are not often related to serious misconduct; and, apart from the occasional effects of the accompanying hypersensitiveness and irritability, neurasthenia (in the proper sense of the term) is comparatively infrequent as a causative factor. In his investigation of 4,000 adolescent criminals, Dr. East found no more than 48 suffering from definite psychoneurosis—not much more than 1 per cent. In all such cases Dr. East once again stresses the importance of early recognition: the more promptly psychotherapeutic measures are applied, the less likely is anti-social conduct to ensue.

In criminological literature the phrase 'psychopathic personality' often becomes (as Dr. East acknowledges) a kind of waste-paper basket, into which anything that cannot be pigeon-holed under more definite headings may all too easily be bundled together. Nevertheless, he believes that there is a small but well-defined group, including schizoid, cycloid and paranoid personalities, as well as perverts, drug addicts, alcoholists and the mentally unstable generally, to whom the term may be usefully applied. The disabilities and social difficulties of the so-called psychopath seem largely due to innate factors; and the prevention of anti-social disorders among such persons consequently presents a serious practical difficulty. Treatment has often to be restricted to efforts designed merely to modify the particular impulse or activity which is leading the patient into conflict with the law.

On the whole, however, as Dr. East insists, "the majority of prisoners found guilty of criminal offences do not show abnormal characteristics (although, of

course, they exhibit individual variations among themselves, just as other groups of persons do). . . . The figures disprove the assertion of those who declare that crime is a disease." Coming from one who, in virtue of his work, his experience, and his writings, is among the foremost authorities on the subject in Great Britain, and is himself a medical man, this is a most significant pronouncement. Both in the medical and in the educational world there are still numerous writers and administrators who do not realize how opinion upon this point has changed. The trouble seems to be that laymen and Government officials are alike inclined to think that the qualified expert in mental science must be the medical man. Psychology, owing doubtless to the publicity given to its more sensational problems, is confused with psycho-analysis, and not yet regarded as a science in its own right. Many of the pioneers who have urged that the prime need of the adult criminal is treatment rather than punishment have done so on entirely misleading grounds, namely, that "crime is a pathological symptom, and therefore the criminal should be accorded the same medical care as any other mental sufferer". Similarly, when child guidance centres were established they were called 'clinics' (as though backward pupils as well as young delinquents were mentally diseased); and it has been the official policy of the Child Guidance Council itself that "since crime is a form of illness, the child guidance clinics at which such cases are examined should be under a medical director". No doubt, in a small proportion of the cases, moral delinquency, like educational backwardness, may be the outcome of physical or mental illness; and in every case the first step is unquestionably to investigate the possibility of such illness as a contributory factor. Recent investigations, however, like those of Dr. East, prove conclusively that it is, as a rule, only a minor factor, and a comparatively rare one at that. Hence, as recent experience has shown, there is considerable danger that exclusive or excessive emphasis on the need for a medical approach may lead to the neglect of other lines of study and treatment that are far more important—the social, the educational, or the psychological.

In all cases of delinquency or crime it is the psychological rather than the physical or pathological characteristics of the individual that call for first consideration. But in early years it is the social and educational environment—the home and the school—that are usually the deciding factors. "The home," says Dr. East, "should be the first training ground." The lad who comes from a broken home or from a family where discipline is unduly harsh, unduly lax, or so erratic as to be virtually non-existent, is not only more liable to drift into vice and crime, but also more resistive to subsequent efforts at reform. A wholesome training in the school is equally essential as a supplement to, and often as the only substitute for, the training in the home. "But its value is not to be measured by its success in teaching a lad how to acquire knowledge or even by its material usefulness in after life: . . . the formation of moral principles and habits is the most important part of education." "For this and other reasons," Dr. East observes, "the criminologist will welcome the proposal to raise the school-leaving age." As regards economic conditions, he finds that the relative amount of unemployment among offenders was not appreciably greater than that obtaining among the general population: but they seemed far more liable to commit their offences

during spells of unemployment than at other times. In particular, he urges the importance of vocational guidance as a means of combating delinquency: among adolescents more especially, it would seem. "wrong placements tend to invite anti-social behaviour".

As to punishment, Dr. East notes that "the tradition that imprisonment is solely punitive still persists in certain quarters; but it cannot be too widely known that its modern purpose is treatment and training". This, as he points out, is the attitude taken in the Criminal Justice Bill of 1938, which was before Parliament before the outbreak of the War. That penal measures do not altogether fail is, in his view, borne out by after records: thus "of 17,918 males and 2,749 females who were over the age of 16 years in 1932, and were found guilty in that year of offences sufficiently serious to warrant the taking of finger-prints, and had no previous proved offences recorded against them, 90 per cent of the older males, and over 70 per cent of the younger, were free from any further charges during the subsequent five years: the figures for females were nearly 90 per cent".

Due attention to the psychological study of the criminal must be one of the items that should claim a foremost place in the programme for post-war reconstruction. Since at the moment the urgent need is knowledge, more detailed, more precise, and, in a word, more scientific, about the reactions of the individual mind, one of the first steps should be to establish "an institution where research into the problems of criminal behaviour, and the scientific treatment of offenders, can be carried out". "And the conclusion of the whole matter," says Dr. East, "seems to lie in the fact that a democratic State can no longer afford to ignore the effects of social hazards which are harmful and preventable; the treatment of delinquent and criminal behaviour are not merely matters that concern lawyers, administrators and scientists; they are matters that concern us all."

A PHYSIOLOGICAL THEORY OF COLOUR PERCEPTION

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IT is nowadays possible to record the discharge of the retinal elements directly by leading off to electrodes from more or less isolated fibres of the optic nerve. The electrical impulses following upon illumination are the physiological means of communication between the retina and the higher centres. They are amplified and led to an oscillograph for photographic recording and at the same time listened to in a loud-speaker. This is the technique for which the well-known work of Prof. E. D. Adrian and his collaborators originally laid a solid basis. For isolation of the fibres in the optic nerve a method of micro-dissection around the blind spot has been developed by Hartline¹ and a micro-electrode technique for picking up from the fibres inside the eye by Granit and Svætichin². The latter method is a great deal simpler and faster than the former, and for this reason it is the natural instrument for a rapid survey of the colour properties of a large number of single or grouped units in the response of the eye to illumination with spectral light of known energy