observed in the animals at birth are highly specific to the age at the time of irradiation, marked differences being seen in some cases when the age is varied by only a few hours. It seems that each region of embryonic tissue has a very short period of extremely high sensitivity to radiation damage, and that this period is the time during which the cells in the region become differentiated and the main line of their future development is laid down. There is a hope that such experiments may throw light on the mechanisms of growth and differentiation, which are still altogether mysterious.

The last article in the book, Practical Aspects of Radiation Injury by Hempelmann and Hoffman, discusses case-histories of people injured by atomic bombs, reactor accidents, and chronic exposure to radiation. These matters have an obvious topical interest to the general public, and the article is highly recommended to anyone who desires exact information and is content with a less colorful presentation of it than is given by the *Saturday Evening Post*.

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Crystal Growth and Dislocations. By Ajit Ram Verma. 182 pp. Butterworths Scientific Publications, London, England; Academic Press Inc., New York, 1953. $5.00.

One of the most significant recent developments in the physics of solids has been the almost dramatic success of the dislocation theory of crystal growth. From the viewpoint of a crystal grower the crystals that grow by the dislocation mechanism form a very small and highly special class. From the viewpoint of research in solid state physics, however, the dislocation growth mechanism is immensely important. The studies in this field have thrown light on a number of fundamental problems. In particular they give the most direct experimental evidence for dislocations and open up one of the most powerful techniques for studying dislocations. The success in this field has been due to the combination of three recent developments: (1) The theory of the atomic nature of a crystal surface in contact with its vapor or dilute solution and the associated theory of surface kinetics and nucleation; (2) the dislocation theory; in particular, the geometrical concept of a screw dislocation which, as F. C. Frank showed, removes the need for nucleation in growth on a close-packed crystal face; (3) the powerful techniques of phase contrast microscopy and multiple beam interferometry which reveal the details of a growth surface on an atomic scale and resolve steps only a few Ångstroms high. These subjects have all been treated before but never in a single book and from a unified viewpoint. Dr. Verma's book is a welcome and timely contribution.

No special postgraduate knowledge of physics is presupposed and no knowledge at all of crystal growth or dislocations. The topics are presented in physical and pictorial terms with the aid of line drawings and illustrative micrographs. Following a brief introductory survey, Dr. Verma introduces the atomic theory of growth of a perfect crystal. He then defines dislocations and describes the geometrical properties that are the basis of their role in crystal growth. A chapter is devoted to optical techniques and in particular phase contrast microscopy; two chapters follow dealing with the experimental observations. Here Dr. Verma is reporting on a phase of the work in which he has made some of the most outstanding contributions. Interferometric techniques are discussed for measuring step heights of a few Ångstroms. The last of the nine chapters discusses miscellaneous subjects including the origins and the motion of dislocations.

The book is clearly written and well-organized. It will be appreciated by physicists, metallurgists, and chemists interested in a specialized but highly important subject.

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Communication Theory. Papers Read at a Symposium on "Applications of Communication Theory", London, 1952. Edited by Willis Jackson. 532 pp. Academic Press Inc., New York, 1953. $11.00.

The mathematical theory of communication (information theory) has been developing for about thirty years; it reached maturity with Claude Shannon's paper in the *Bell System Technical Journal* in 1948. The publication rate since then has been high. A person not working primarily in communication engineering, but interested in its possible applications to his own work, can hardly read every paper; to such a person, the volume under review will be very useful. It can be read, with reasonable understanding, by a reader initially acquainted only with Shannon's paper. It covers a number of different areas of application. And it has been put together with unusual editorial skill: it has a continuity of subject matter and a uniformity of symbolism seldom attained in a symposium collection.

The basis of the new theory is a quantitative definition of *amount of information*. When an event occurs whose probability was p, the event is said to communicate an amount of information $\log (1/p)$. This definition makes information additive for independent events, and dependent in a reasonable way on the probability: for instance, an event that we know is going to happen ($p = 1$) conveys no information by happening. If n independent symbols have probabilities $p_1, p_2, \ldots, p_n$, then an N-symbol message with N_1 occurrences of symbol 1, N_2 of symbol 2, etc. communicates an amount of information $-\Sigma_i N_i \log p_i$. Previously (1922), R. A. Fisher had based his theory of statistical estimation on essentially this same quantity; he applied the term "information" not to it, but (1925) to a quantity derived from it. Fisher remarked (1935) that information (in his sense) "is strikingly similar to entropy"; that "irreversible processes . . . may be accompanied by a loss, but never by a gain". In Shan-

non's theory, the quantity of greatest interest is the mean amount of information per symbol in a representative collection of messages. This is $-\Sigma_i p_i \log p_i$, which again suggests a thermodynamic analogy and which was called by Shannon the *entropy* of the set of probabilities p_i.

One result of Shannon's paper was a revival of the discussion of Maxwell's demon, who now turns out to be an informed demon. But the reader interested in this topic will have to look elsewhere, for the 1952 symposium was devoted rather to applications of the theory within its original field. The interpretation of that field was broad enough to permit inclusion of papers on hearing, speech, language, and semantics; but the majority of the papers (24 out of 39) deal with electrical communication. They are grouped under four general topics: transmission systems and coding, transmission in the presence of noise, transmission-channel characteristics, and television. A fact clearly evident is that the theory has demonstrated a tremendous inefficiency in present telephone and television transmission, and has stimulated interest in the development of more efficient methods.

Most of the papers are followed by discussions. These are lively and frank; the usual polite generalities are often dispensed with. It seems that the experts on communication theory have the same communication difficulties as the rest of us.

Two things I looked for but did not find. One is an explanation of the relation between the concepts of communication theory and those of the theory of statistical estimation. The other is an application of communication theory to the problem of library indexing and searching by machine methods. It is nevertheless true that communication theory has stimulated exchanges of ideas between workers in different and previously noninteracting fields. In this book there are, for instance, significant (and even violent) interactions between linguists who dare to speak up among engineers, and engineers who dare to try to measure language. I think this is good; let us have more of it.

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Principles of Color Photography. By Ralph M. Evans, W. T. Hanson, Jr., and W. Lyle Brewer. 709 pp. John Wiley and Sons Inc., New York, 1953. $11.00.

"Color photographic processes are chemical in nature in that the colorants (usually dyes) of the photograph must, in general, be chemically formed. The color reproduction characteristics of the process, however, are evidenced by the optical characteristics of the dyes after they are formed rather than by chemical reactions. The chief emphasis in the present work is upon these physical characteristics and upon the attendant effects which the picture may have on the observer. These effects are considered in both psychophysical and psychological terms. The chemistry of color photography is discussed to the extent of indicating the nature of the photographic materials and of the major chemical reactions involved in various types of color systems. . . ."

The initial chapters discuss color specification and measurement, the response of the eye to light in simple and complex situations, the relationship of the color photograph to the original scene, and the various factors that are involved in obtaining an acceptable print. The response of photographic materials and the formation of the colored image are then treated in detail. This is followed by a nontechnical chapter on various ingenious color photographic systems, both practical and impractical; it is of interest to note in connection with this that Clerk Maxwell presented the first demonstration of a photograph in color in 1861. The following chapters deal with theories of color formation, the chemical and optical properties of colorants, the measurement of densities, and color sensitometry. The final chapters treat the theories of duplicating, copying, and additive and subtractive processes of color reproduction. (The distinction between duplicating and copying is that in the first process the dye systems of the original and final prints are identical, whereas they differ in the second; matching of the prints can be accomplished by physical means in the first case, but visual means are required for the second.) The book ends with a twenty-page bibliography.

This comprehensive (although black and white) treatise on color photography will no doubt become the standard reference on the subject. It is a serious book: the only feminine photographs it contains are those of a draped Grecian bust, and this, as well as the background in physics, chemistry and mathematics the book requires, will preclude its use by laymen and popular photographers. Although it is directed primarily to research workers in the field, it will prove valuable to those using photography as an experimental tool, as well as to those dealing with practical problems related to colorimetry and the psychological aspects of color vision.

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Introduction to Tensors, Spinors, and Relativistic Wave-Equations (Relation Structure). By E. M. Corson. 221 pp. Hafner Publishing Company, New York, 1953. $10.00.

The theory of elementary particles deals with wave equations which describe the motion of a single particle with spin. The most familiar of these is, of course, the Dirac equation for a particle of spin 1/2, the Klein-Gordan equation for particles of spin 0, and the Kemmer-Proca equation for spin 1 particles. Once such equations are formulated, the corresponding fields must be quantized, and their interaction with other fields, particularly the electromagnetic field, must be introduced. The questions which arise, for example, the connection between spin and statistics, are of a fundamental nature and are thus most fascinating to theoreticians. Unfortunately, the theories are not intimately