fundamental facts needed to enable the student to get a properly proportioned picture of an important individual industry. Too much detail can not be indulged in or the book soon becomes encyclopedic and the relationship and interdependence of related industries is lost sight of. German text-books on chemical technology, like Wagner's well-known work, become ultimately too bulky to be available as text-books, and of quite a number published in that language there is at present only one that may be called sufficiently inclusive and yet remains compacted into one volume of modern size, viz., Ost's "Chemische Technologie," which has in consequence run quite rapidly through many editions.

Professor Thorp planned at first to omit metallurgy because it was generally treated separately in special text-books, but he has reconsidered this, and Part III. of the present edition is devoted to metallurgy. He has sought to economize space by leaving the chemistry of coal-tar colors out of special consideration, although a classification of them according to the conditions of their application in dyeing processes has been found necessary. With the awakening interest in the establishment of an American dye-color industry, it will probably be found desirable to take up the chemistry of coal-tar intermediates and ultimate color products for all advanced chemical students. When congressmen and the daily newspapers begin to discuss the merits of our new dye-color tariff, the graduates of our technical schools must be ready to talk intelligently on the subject.

The new edition of Professor Thorp's book covers, however, a great range of important subjects and covers them well, presenting the outlines of processes clearly and making the subject interesting to the reader or student.

As an illustration we would note the article on Glass Manufacture on pp. 196 et seq. The presentation shows the clearness of view acquired by the teacher who has learned clarity of expression by the experience of the classroom. The same may be said of the section on Pigments, p. 222, which is excellent in form and substance. If we may be allowed to criticize the treatment of some of the sections, we would say that the asphalt section is hardly adequate in its handling of either the chemistry or the technology of this important subject, and the present view of asphalt as polymerized petroleums rather than oxidation products is not mentioned.

Similarly under the Match Industry we find no mention of the use of P_4S_3, phosphorus sesquisulphide, in the manufacture of the "strike-anywhere" matches which have come in with the legislation against the use of white phosphorus for match compositions.

The modern theories with regard to colloids are noted and in several sections, the phraseology of modern colloid chemistry has been applied to explain fundamental phenomena. We can not be sure that the understanding of these processes has always been improved by this unreserved application of colloid theories, as, for example in the explanation of leather manufacture on p. 573.

The book, however, as before said, is generally up to date and clearly written, with a uniformity of method of presentation which makes it much better for a text-book than works made up of contributed articles of varying degrees of value from a number of writers.

S. P. Sadtler

Urgeschichte der bildenden Kunst in Europa von den Anfängen bis um 500 vor Chr. Von M. Hoernes. Zweite durchaus umgearbeitete und neu illustrierte Auflage mit 1330 Abbildungen im Text. Mit Unterstützung der Kais. Akademie der Wissenschaften in Wien. Wien 1915. Kunstverlag Anton Schroll & Co., Ges. M. B. H. Pp. xiv + 661.

The period elapsing since 1898, when the first edition of this important work appeared, has been one of marked progress in our knowledge of prehistoric art. The author, being able to take full advantage of the opportunity, has made of the new edition practically a new work.

The first part deals with primitive art in general. Geometric art is found to be neither older or younger than realistic art. One can say however that it is the more common, the

easier; in fact among some races it is the only art, and hence among such presumably the older. In other cases it plays a secondary rôle. In Europe at least it appeared only after a long and brilliant period of naturalism. The realistic art of the Cave period may be looked upon as the art of the male, and that of the neolithic period as that of the female; in other words sex is supposed to be at the basis of the differences between realism and conventionalism. The making of basketry and pottery was the work of woman, and their ornamentation, the product of her mind. In this cleavage religion, or the absence of it, might also have had something to do; for the tendency of religious art is toward the conventional, while that of profane art is toward the natural. Thus in the opinion of the author idols were unknown until the neolithic age.

Our conception of prehistoric art is of necessity based on partial evidence only. We can know nothing of the then existing dance, music and poesy; and very little of art as expressed in personal adornment.

It is justly pointed out that the differentiation between the historic and the prehistoric does not consist in a knowledge of any particular one of the three principal metals of antiquity; for in the Orient the historic period long antedates the closing of the bronze age, whereas the historic period in Europe begins during the iron age. Differences equally marked are to be noted elsewhere. The negroes of Africa, for example, with their knowledge of iron, have not yet reached so high a stage of culture as did the prehistoric peoples of Central and South America, among whom the use of iron was absolutely unknown.

The three great culture stages in Europe—the paleolithic, the neolithic, and the age of metals—correspond to three great phases of art: *Jägertum, Bauerntum,* and *Herren-* or *Kriegertum.* The art of the hunter stage lasted longest and reached its highest development in western Europe, especially southern France and northern Spain; that of the peasant stage took deepest root in central and northern Europe; while the martial stage first came to fruition in southern Europe. The art of the first stage was naturalistic, of the second geometric, and of the third a return to a higher realism under the control of conventionalism.

The author takes issue with Breuil respecting the age of the wall paintings of southern and southeastern Spain. From the viewpoint of art these certainly differ from the paleolithic mural art of the Cantabrian region. It is probable therefore that they belong to a later epoch, even later than the Azilian, although many of the designs on the painted pebbles of Mas d'Azil have their counterparts in the mural art of southern Spain as recently noted by Obermaier.

For Hoernes the Cave art of southern France and northern Spain is a highly specialized type, a peripheral culture phenomenon. Hence from it the art of the succeeding epochs did not and could not spring, because of a well-known law in evolution that highly specialized types of one geologic horizon do not give rise to the types of subsequent epochs.

In the field of ceramic art Hoernes distinguishes two fundamental methods of ornamental treatment: the *Umlaufstil* and the *Rahmenstil.* The first with its space-filling banded ornament is supposed to be the older, although neither is wholly confined to the neolithic period. The second with its panel ornamentation goes logically with the various forms of handled ware. The banded style, on the other hand, is expressive of ware without handles; to it belong the spiral and meander decoration.

During the bronze age the best examples of decorative art are to be seen in metal work; this is especially true of northern Europe. It was during this age that plant motives first appeared.

The passage from the bronze age to the iron age took place slowly, at first in the Orient and in Egypt; in Greece about 1200, in Italy 1100, and in central Europe about B.C. 1000. In the ceramic field the Hallstatt epoch is not so much an outgrowth from the bronze age as from the neolithic age. The banded as well as the panel style of the Hallstatt epoch is foreshadowed in the neolithic pottery of

east central Europe. The Dipylon and the Villanova style representing the earliest phase of the iron age in Greece and Italy, respectively, both abound in banded and panel patterns, especially the meander and the swastika. (The swastika is supposed to date as far back as the neolithic period.)

The art of the smith made rapid strides during the Hallstatt epoch. A process was developed of at least superficially hardening a blade of iron, although steel proper was as yet unknown. The engraved ornaments of the bronze age now give place largely to embossed patterns produced by hammering. With the epoch of La Tène the art of the third and last great stage (Kriegertum) spread over western and northern Europe.

The revision is everywhere both conservative and thorough; some thirty pages of addenda and references will contribute much toward its usefulness as a source book.

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THE MECHANISM OF LIGHT PRODUCTION IN ANIMALS

It has long been known that the dried powdered luminous organs of the fire-fly will glow if moistened with water containing oxygen. No light is given off if oxygen is absent. In a previous issue of Science I pointed out that if we allow this dried powder to stand for an hour in contact with water carefully freed of its dissolved oxygen and then admit oxygen, no phosphorescence is to be observed. It is quite obvious that the photogenic substance has been changed in some way even though no oxidation has taken place. The substance, therefore, which in presence of oxygen is oxidized with the production of light, in absence of oxygen is also decomposed but without light production. We have an analogous instance in the compound lophin (triphenylglyoxaline) investigated by Radziszewski. If hydrolyzed in presence of oxygen by alcoholic potassium hydrate, light is produced and benzoic acid and ammonia formed. In absence of oxygen, no light is produced and benzaldehyde is formed instead of benzoic acid. The alkali acts as a catalyzer.

In the fire-fly it is natural to suppose that an organic catalyzer, an enzyme, is concerned in light production and it is the purpose of this paper to point out the fact that the existence of such an enzyme has been definitely proved and to add certain new facts to our knowledge of bioluminescence. The credit of this discovery belongs entirely to Professor Raphael Dubois, of the University of Lyons. As early as 1884 Dubois made the crucial experiments in which he showed that two substances are present in the luminous organs of *Pyrophorus noctilucus,* the West Indian cucullo, a thermostabile substance, luciferin, which oxidizes with light production and a thermolabile enzyme luciferase. In 1887 Dubois showed that the same was true for the luminous mollusc, *Pholas dactylus.* If the luminous slime from glands on the siphon and mantle of this mollusc are collected in sea water in two test tubes the solutions will phosphoresce for some time. Boil the solution in one tube and the light disappears instantly; allow the solution in the other tube to stand until the light disappears spontaneously. Then if both tubes, now dark, be mixed, the light reappears. The boiled tube contained luciferin but no luciferase while the other tube contained luciferase but all the luciferin had been oxidized by standing. On mixing, the two substances were again brought into contact and light resulted. In later papers Dubois has studied especially the properties of the *Pholas* luciferin and luciferase and the results are published in many papers in the *C. R. Acad. Sc. Paris* and the *C. R. Soc. Biol.* He says that luciferin is an albumin having acid properties and an active reducing power. It oxidizes readily with luciferase, potassium permanganate, barium peroxide and lead peroxide, giving off light and forming amino-acids and minute crystals giving the test for xanthin.

Luciferase, on the other hand, has all the properties of an enzyme, an oxidizing enzyme acting in the presence of iron salts, which will oxidize luciferin and also tannin, guaiac, a-